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THE DAILY ENERGY REQUIREMENTS OF A WILD ANNA HUMMINGBIRD

By OLIVER P. PEARSON

The daily energy requirements of wild, unfettered birds are difficult to estimate because the metabolic costs of flying, hopping, scratching and other common activities are not known, and were they known, it would still be almost impossible to divide a bird's day neatly into periods spent at the different energy levels. Hummingbirds, however, spend almost their entire active day at only two metabolic levels, hovering and perching, and their rate of metabolism during these activities is known. Therefore, to calculate the energy expenditure of a wild hummingbird, one has only to watch a hummingbird all day and record with a stopwatch how much time is spent in the air and how much is spent perching. I shall report below two such attempts to watch a male Anna Hummingbird (*Calypte anna*) on September 3 and September 8, 1953, in the botanical gardens of the University of California at Berkeley.

METABOLIC GROUNDWORK

Before calculating the energy balance of this bird for the day, it is necessary to estimate his rate of metabolism while hovering and while perching. On the basis of previous work (Pearson, Condor, 52, 1950:145), I shall assume that Anna Hummingbirds while hovering consume oxygen at the rate of 68 cc per gram of body weight per hour. In the absence of evidence to the contrary, the energy cost of linear flight will be assumed to be the same as for hovering. Should this assumption prove to be unsound, only a slight error will have been introduced because only a small fraction of the air-born time is spent in linear flight.

For calculating the metabolism of hummingbirds perching at the temperatures encountered in the wild, two 24-hour recordings of oxygen consumption of captive Anna Hummingbirds are available (fig. 1), one at 24°C. and one at 12°. The 24° run has been reported earlier (Pearson, *op. cit.*). These records were obtained in a modification of the apparatus described by Morrison (Jour. Biol. Chem., 169, 1947:667). The bird was confined under a belljar whose inside dimensions were six inches in diameter and four inches high, a space too small to permit flight. Containers of soda lime and calcium chloride served to absorb the water vapor and carbon dioxide produced by the bird, and a generous supply of food was provided. The belljar with the bird inside was submerged in a water bath of appropriate temperature and was connected to a floating spirometer that supplied oxygen at atmospheric pressure. The chamber was illuminated by natural daylight. The bird was weighed at the beginning and end of each 24-hour run and his weight at any time during the run was estimated by interpolation. Results are given in cubic centimeters of oxygen consumed per gram of body weight per hour. The volume of oxygen has been corrected for water vapor and temperature and therefore corresponds to dry gas at 0°C. For conversion to Calories, I have assumed each liter of oxygen consumed to be equivalent to 4.8 Calories, a value appropriate to the respiratory quotient of actively digesting small birds (Kendeigh, Jour. Exp. Zool., 96, 1944:1).

From the data on which figure 1 is based, I calculate that the daytime perching

metabolism (including activities such as preening) at 24° is 16.3 cc/gm/hr and at 12° is 21.0 cc/gm/hr. The mean hourly daytime temperature in the shade on the observed hummingbird's territory on September 3 was 17.3°, and on September 8, 18.1° (fig. 2). The resting metabolism at these temperatures was calculated by linear interpolation between 16.3 and 21.0 cc/gm/hr. Body weight was estimated at 4.0 grams.

Finally, before calculating the total energy expenditure of this wild hummingbird for a 24-hour period, one must assign a metabolic rate for overnight. It has been shown

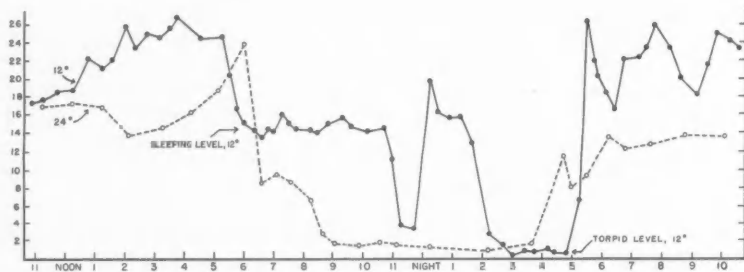


Fig. 1. The 24-hour metabolism of two male Anna Hummingbirds, one at 12°C. and one at 24°. The bird at 12° reached a sleeping level of 14.5 cc/gm/hr at about 6 p.m. and continued at this level until it dropped abruptly into torpor at 11 p.m. However, before reaching the minimal level, its metabolism reversed and the bird, for no apparent reason, emerged from torpor only to drop a short time later to a level of only 0.76 cc/gm/hr. During the 24° as well as the 12° run the birds emerged from torpor spontaneously before daybreak. The torpid level at 12° is somewhat lower than at 24°, but close comparison cannot be made because the accuracy of the apparatus is not great at such low levels of oxygen consumption.

that Anna Hummingbirds frequently pass the night in a condition of torpor at an extremely low metabolic level (Pearson, *op. cit.*, and fig. 1), but on the other hand an incubating female observed by Howell and Dawson (Condor, 56, 1954:93) did not become torpid. It is probable, furthermore, that many hummingbirds in the wild spend part of the night torpid and part merely sleeping, as did the bird whose metabolism was measured at 12° (fig. 1). Therefore, I have made two sets of calculations, one assuming that the night was spent entirely at the sleeping level at an environmental temperature of 12°, and one assuming that the night started as in the 12° run illustrated in figure 1, but that metabolism dropped to the 0.76 cc/gm/hr torpor level at 8 p.m. and remained there until the pre-dawn rise at 5 a.m.

RESULTS

Early in September, when the observations were made, male Anna Hummingbirds vigorously defend a small feeding territory. The territory of the male under observation was only 50 feet in diameter. He rarely left this territory except to chase other hummingbirds, and he drove off every hummingbird that he saw on his territory, regardless of its sex. At dusk, however, he flew off more than 300 feet to his night roosting place.

Figure 3 reveals that he was especially active in the mornings and in the evenings and relatively inactive during the early afternoon. He was flying only 10 per cent of the time early in the afternoons but as much as 30 per cent of one hour just before dark. During his active day, which was 12 hours and 52 minutes long on both days, he averaged 18.7 per cent of the time flying on September 3 and 17.9 per cent on September 8. The longest perching period was between 1:05 and 1:35 p.m. on September 3, although

during a brief observation period on September 1 I noted that he remained perched for as long as 34 minutes between 1:27 and 2:01 p.m.

Using the metabolism data given earlier, one can calculate the daily energy values presented in table 1 and illustrated in figure 4. Assuming torpidity at night, the energy exchange of this bird for 24 hours of normal life in the wild was 7.55 Calories (average of two days), and assuming sleep at night, 10.32 Calories. This is, of course, a consider-

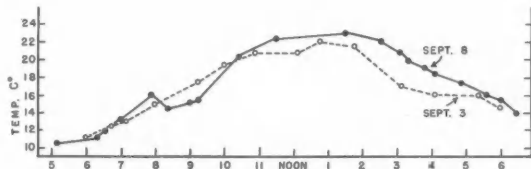


Fig. 2. Shade temperatures on September 3 and 8 on the territory of the hummingbird under observation.

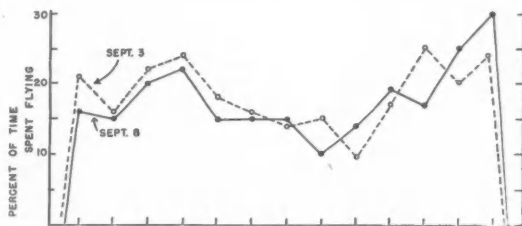


Fig. 3. Per cent of each hour spent airborne. Same male Anna Hummingbird on two days.

ably higher metabolic rate than that of the birds confined in the metabolism apparatus, which totalled 4.88 Calories at 24° and 6.77 Calories at 12°. Agreement is good, however, with the results of some feeding experiments reported by van Riper (*Nature Mag.*, 54, 1953:135). He found that a 4.3-gram Broad-tailed Hummingbird (*Selasphorus platycercus*) removed 7.31 Calories of sugar solution from a feeder each day.

The male Anna Hummingbird's day (fig. 4) can be divided into three major metabolic levels that are at the same time crude categories of activity: daytime perching, flying, and night roosting. If the bird spends the night at the sleeping level, rather than in torpor, then one-third of his 24-hour energy budget is spent in each of these three activities, although his time is spent in an entirely different ratio.

The category "flying" can be subdivided successfully into the following activities: 1. Nectar flights. By far the largest part of his flying time and flying energy could be assigned to this category. 2. Insect-catching flights. These consisted of forays of only a few seconds, similar to the insect-catching flights of flycatchers. The prey was usually gnats. 3. Territory defense. Usually chases in which an intruding hummingbird was pursued, but occasionally flights to the edge of the territory to forestall trespass by a nearby hummingbird. 4. Perch changes. Short flights to a nearby perch for no obvious reason. 5. Disturbances. Short flights of a few yards to avoid workmen and visitors in the botanical gardens. 6. Unclassified flying. The bird was out of sight during 1.5 to 2.0 per cent of each day. After each disappearance an estimate was made of the prob-

Table 1
Time and Energy Values for Two Days of Activity of a Male Anna Hummingbird

	Basic data		Per cent of daytime activity		Per cent of 24 hours		
	Time	Energy	Time	Energy	Time	Energy assuming torpidity	Energy assuming sleep
Daytime activity	12 hr. 52 min. (12:52-12:52)	6.88 Cal. (6.95-6.80)	100	100	53.7 (53.7-53.7)	91.2 (91.3-91.1)	66.6 (66.8-66.4)
Perching	10 hr. 32 min. (10:28-10:36)	3.81 (3.82-3.80)	81.8 (81.4-82.2)	55.5 (55.0-55.9)	43.8 (43.6-44.1)	50.5 (50.1-50.9)	36.8 (36.7-37.0)
Flying	2 hr. 21 min. (2:24-2:18)	3.07 (3.13-3.00)	18.2 (18.7-17.9)	44.6 (45.1-44.2)	9.8 (10.0-9.6)	40.7 (41.2-40.2)	29.7 (30.1-29.3)
120 (120-119) nectar- feeding flights	1 hr. 53 min. (1:58-1:49)	2.46 (2.55-2.37)	14.6 (15.2-14.1)	35.7 (36.7-34.8)	7.85 (8.15-7.55)	32.5 (33.4-31.7)	23.8 (24.5-23.1)
Chasing 78 (108-67) insects	4.45 min. (5:50-3:40)	.094 (0.110-.077)	0.54 (0.65-.044)	1.34 (1.58-1.10)	0.30 (0.35-.024)	1.22 (1.44-1.00)	0.90 (1.06-.075)
50 (47-53) territory defenses	13.76 min. (10:00-17:52)	0.305 (.230-.379)	1.8 (1.3-2.3)	4.48 (3.34-5.61)	0.96 (.70-1.22)	4.08 (3.05-5.11)	2.96 (2.22-3.70)
60 (70-50) perch changes	2.75 min. (3:37-2:13)	.058 (.072-.043)	0.36 (.44-.28)	0.85 (1.04-.066)	0.19 (.23-.15)	0.78 (.95-.60)	0.55 (.69-.42)
39 (64-14) dis- turbances	0.65 min. (1:07-.23)	.014 (.024-.005)	.08 (.14-.03)	0.20 (.32-.09)	.04 (.07-.01)	0.18 (.29-.08)	0.14 (.23-.05)
Unclassified flying	6.87 min. (7:50-6:25)	0.148 (.163-.134)	0.89 (.97-.81)	2.17 (2.35-2.00)	0.45 (.47-.43)	1.97 (2.14-1.81)	1.44 (1.57-1.31)
Night roosting (torpid)	11 hr. 8 min. (11:08-11:08)	0.672			46.5 (46.5-46.5)	8.91 (8.83-9.00)	
Night roosting (asleep)	11 hr. 8 min. (11:08-11:08)	3.446			46.5 (46.5-46.5)		33.3 (33.1-33.6)

able time spent flying, the estimate depending upon what the bird was doing when it disappeared and how soon it returned. All such estimates of flying time were then added to make up the "Unclassified Flying" category. Figure 4 and table 1 divide the bird's day into these activities. In table 1 the average figure for the two days is given as well as, in parentheses, the separate value for September 3 followed by that for September 8. The values for the two days agree surprisingly well.

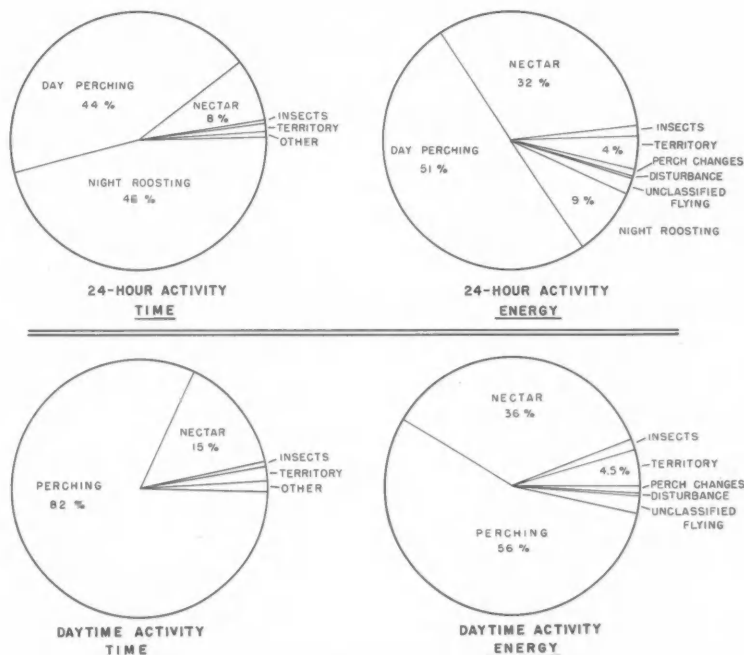


Fig. 4. Upper. Expenditure of time and energy by a hummingbird for 24 hours; average of September 3 and 8. The energy diagram was constructed assuming that the bird became torpid at night.

Lower. Expenditure of time and energy during the 12-hour, 52-minute active day. Same observations as above but the night period at unknown metabolic level has been omitted.

The hummingbird under observation did approximately 90 per cent of his nectar feeding from the blossoms of a single large bush of *Fuchsia macrostemma*. On a few occasions when his attention was directed elsewhere another bird managed to feed for a short period on these blossoms. If we assume that this pilfering just balances the nourishment that the resident bird obtained feeding on insects and on other flowers, then it becomes possible to say that the 7.6 (assuming torpidity at night) to 10.3 Calories (assuming no torpidity) required every day by this bird could be supplied by nectar from the 1022 blossoms available on this bush.

The value of defended territory to an individual bird or to a species is difficult to measure and to put into quantitative terms, yet the concept of territories is basic in the

study of bird behavior and avian ecology. It is probably safe to assume that the true value of territorial defense to an individual or species is greater than the cost, otherwise the habit would have been eliminated through centuries of evolution. If, then, one can calculate how much energy a bird spends defending its territory, one has a minimal estimate of the value received by the bird as a result of its expenditure. In figure 4 and table 1 can be seen the cost of territorial defense to this hummingbird. The cost is expressed in Calories, an international currency that lends itself to comparison of the territorial defense costs of the same individual on different days, at different seasons, or even of comparing the defense costs of widely different species. The male Anna Hummingbird watched on September 3 and 8 devoted 1.8 per cent of his 12-hour 52-minute active day to an average of 50 flights in defense of his territory. This amounts to 0.305 Calories, 4.48 per cent of his daytime energy expenditure, or 4.08 per cent of his 24-hour metabolic needs (assuming torpidity at night). In more tangible units this represents the energy derived from 42 blossoms of *Fuchsia macrostemma* (4.08 per cent of 1022). This is the expense of active defense of his territory. Probably a small fraction should be added for the cost of territorial singing. Perching of the bird in conspicuous places where he can be seen by birds on neighboring territories can also, like singing, be considered a kind of territorial advertisement, but unless such perches require more energy to reach than do alternate perches no allowance need be made for this territorial display because it does not necessitate increased metabolism.

It will be seen from figures 3 and 4 that only about one-fifth of the daytime is spent on the wing. Of the remaining four-fifths, a small fraction is necessary for preening to keep the plumage in serviceable condition and probably a small fraction is required for rest, but the remainder of the perching time is available for more strenuous activity should occasion demand. At some seasons the territory must be considerably larger to allow gathering of sufficient food, and at such seasons more time and energy would be spent feeding and less perching. During the early spring considerable energy must be expended in the spectacular diving display, thereby necessitating more feeding. Each hour of flight not only subtracts that much time from the perching time, but necessitates approximately 15 minutes more of flying to replace the *additional* food consumed during the hour of flight. Accordingly figure 4 may be expected to have a quite different appearance if plotted for other seasons of the year. It is my impression that early September, despite vigorous territorial defense, is a time of abundant food, small territories, and relative inactivity. It is a season of leisure for the Anna Hummingbird.

SUMMARY

A male Anna Hummingbird watched on September 3 and 8 flew on the average 18.7 per cent of the time. His energy exchange for 24 hours of normal life in the wild was calculated to be 7.55 Calories (assuming torpidity at night) or 10.32 Calories (assuming sleep at night). During his 12-hour 52-minute active day, most of his energy expenditure was distributed as follows: perching, 3.81 Calories (56 per cent); nectar flights, 2.46 (36 per cent); insect-catching flights, .09 (1.3 per cent); and defense of territory, .30 (4.5 per cent). The nectar secretion of about 1022 *Fuchsia* blossoms can supply this daily need.

Museum of Vertebrate Zoology, Berkeley, California, August 13, 1954.

REDISCOVERY OF THE NESTING OF THE DARK-RUMPED PETREL
IN THE HAWAIIAN ISLANDS

By FRANK RICHARDSON and DAVID H. WOODSIDE

The Galapagos and Hawaiian races of the Dark-rumped Petrel (*Pterodroma phaeopygia*) constitute the only forms of a little known species. Murphy (1936:697-699) gives a description and records of the oceanic distribution of the Galapagos race (*P. p. phaeopygia*) but little on its breeding habits. He describes Beck's discovery of a nesting burrow in a humid, thickly vegetated zone at about 1000 feet altitude on Indefatigable Island and the collection of one of the only two known eggs preserved of the species.

The Hawaiian race of the Dark-rumped Petrel, or Uau (*P. p. sandwichensis*), was well known to the ancient Hawaiians, who took both adults and young for food, but apparently little was learned or recorded about it by collectors and observers of the last century. When Bryan (1908:50) collected adult birds from their nesting burrows on Molokai in 1907, the species already seemed to be much reduced in numbers. It was almost unheard of after this until 1948 when Baldwin and Hubbard (1949:231) obtained a live adult on Kilauea on the island of Hawaii. These authors summarize much of the meager knowledge of the species in the Hawaiian Islands.

During the fall of 1953 and the spring of 1954 sufficient new information was obtained on the Hawaiian subspecies to justify a review of its present status and presentation of additional notes on its habits. On October 22, 1953, an Uau was obtained on the Hawaiian island of Maui by Joseph Medeiros of the Territorial Division of Fish and Game. The bird was apparently the first from Maui, and, being in juvenal plumage, proved that the species was still breeding. The bird was fully fledged and had adult wingspread, but small patches of brownish down remained on the wing coverts and belly. It was found alive in a reservoir near Kahului, Maui, a low, agricultural region of the island, to which it presumably flew. The petrel died at the Honolulu Zoo on October 25, and it was prepared by George C. Munro, Associate in Ornithology of the Bishop Museum of Honolulu, who noted that the bird was very fat. The skin was given to the Bishop Museum.

In the spring of 1954 five more records of the Uau, all remains of dead birds, became known from the island of Hawaii. On April 29, Woodside found the complete remains (now a skeleton in the Bishop Museum) of one of these petrels, dead at least several weeks, near Kanahaleonui at over 9000 feet altitude on the east slope of Mauna Kea. He also then found some of the feathers and part of the beak of another individual recently killed by a cat at about 10,000 feet on the south slope of Mauna Kea. Harry Fergerstrom, Forest Ranger for the Territorial Board of Agriculture and Forestry, obtained the remains of three more Dark-rumped Petrels, all from above 9000 feet on the east slopes of Mauna Kea. One was killed early in June, probably by a cat. All these records suggested that the petrels might still be coming to a breeding area high on Hawaii, even though 50 years had elapsed since they were reported doing so.

In 1951, Bonsey wrote (1951:32) of hearing nocturnal bird cries, perhaps of petrels, in Hawaii National Park in the crater of Haleakala on Maui. The possibility of petrels occurring and breeding on Haleakala had not been investigated in the ensuing years. Accordingly, the authors undertook a search in the crater from June 5 to 9, 1954. Numerous bird calls and other notes were heard from the first night on, both above the Holua Cabin region near the west floor of the crater and above the Kapalaoa Cabin which is below the south rim of the crater. However, in spite of search both night and day, no bird was found until the night of June 8. At this time, several petrels were seen

in flight and an adult Dark-rumped Petrel was obtained from one of two freshly used burrows that had been found about a quarter of a mile south of the Hofua Cabin. The bird was on an egg, thus establishing the fact that the species is still breeding in the Hawaiian Islands and in a mountainous habitat heretofore undescribed.

The general breeding habitat (fig. 1) can be described as the steep slopes and cliffs making up the walls of the crater of Haleakala. The rim of the crater runs from about 8000 feet in elevation to 10,025 feet, and the floor below the rim is chiefly between 6750 and 7250 feet. The crater walls are old and eroded and so have a good deal of soil and vegetation. The drier, soil-bearing slopes are largely covered by the grass



Fig. 1. West wall of Haleakala Crater, Maui, from floor of crater. Occupied petrel burrows were found in lower center, near white cliffs.

Deschampsia australis and bracken fern, *Pteridium aquilinum*. The dominant plant on the rocky, usually more moist slopes, and around cliffs, is the Pukiawe bush (*Styphelia tameiameia*).

The location of the two occupied petrel burrows we found was at the base of small cliffs. The entrances were in dirt; these led into deep natural cracks between buried rocks. Both burrows went in over six feet. The petrel obtained was more than five feet within its burrow, beyond two right-angled turns. Nesting material consisted of about double handfuls of dry grass in each case and was placed about four feet from the entrances. The entrances were small (less than 6 by 8 inches) and showed almost no sign of recent digging. Probably the burrows had been used for many years, a surmise substantiated by finding the aged partial skeletons of two adult Uau in one burrow.

Bryan describes the Uau as nesting in 1907 in partly natural burrows beneath tree trunks in the wet, forested region at some 3500 to 4000 feet altitude on eastern Molokai. These conditions seem comparable to those associated with the nesting of the Galapagos form, for Murphy describes a burrow dug through dense soil and roots. In view of these records it was the more surprising to find the petrel nesting in a high, rocky, relatively barren area. The digging ability of the bird must lie chiefly in the heavy head and beak rather than in the legs. As an indication of this, the tarsi are relatively short and light compared to those of the Wedge-tailed Shearwater (*Puffinus pacificus*) which actively

uses its legs in digging a large burrow. The *Uau* cannot fly readily, if at all, from a level, vegetated area, so the steep, open nesting sites on *Haleakala* must be especially suitable for taking flight. Presumably when the bird nests in an overgrown region it must walk to an exposed steep slope for taking off.

The egg found in the burrow with the Dark-rumped Petrel on June 8, 1954, was collected, since it had been accidentally cracked. It measured 62 by 44 mm. (larger than the two known eggs from the Galapagos Islands which are 61.4 by 44.1 mm., and 61.5 by



Fig. 2. Site of occupied burrow in crater. Burrow was in lower center next to block of rock some 6 feet high.

39 mm.) and was pure white and bluntly ovate. It contained an embryo, still alive 18 hours after incubation had been stopped and the egg had been carried many miles. The embryo was judged to be about three weeks old, indicating a laying time in mid-May. This is much earlier than the July laying thought typical by Bryan of the *Uau* on *Molokai* but agrees with the laying dates of April and May given by Munro (1944: 26). Interestingly, the related Bonin Island Petrel (*Pterodroma leucoptera*) of the western Hawaiian Chain lays in the fall.

Bryan (1907:48) appears to have been the first person who attempted to describe the vocalizations of the *Uau*, and he speaks of a "long, drawn out *u-a-u*, suggesting the wail of a lonesome cat" and an answering "*uau, ka-ka-ka-ka-ka* . . . combining such a number of . . . sounds as to render it both indescribable and unforgettable." Although thinking they were from Bulwer Petrels (*Bulweria bulweri*), Bonsey (1951:32) describes the calls: "*o-o-o-we*—drawn out on the first syllable and rising to a short bark on the second, and moans, short barks, and rumblings like a tractor engine."

Although we agree that it is difficult to describe adequately the numerous and often eerie sounds made by the *Uau*, some further attempt seems worthwhile. The most frequent call, usually starting soon after dusk, is a repeated *ā-ōō* with an inflection on the *ā* often making it a sharp note, and the *ōō* lasting about a second. The *ōō* may sound, especially if heard nearby, like a complex of growling squeaks, and may be followed by a sharp *kee-kee-kee*. Additional notes are a nasal, drawn-out *ē*, a croak-like note, and a high-pitched *witch* note.



Fig. 3. Adult Dark-rumped Petrel taken from burrow at Puu Kole on Mauna Kea, Hawaii, June 13, 1954.

Adding greatly to the observations made on Maui, Woodside and Fergstrom discovered, on June 12, 1954, five fresh Uau burrows near Puu Kole just over 9000 feet altitude on the southeast slope of Mauna Kea on Hawaii. All the burrows were located under old lava flows and all were over six feet long. Two of them contained birds (fig. 3), and at least one an egg. The nesting material in one was dry bracken and a little grass. The habitat (fig. 4) was similar to that at Haleakala but there were no cliffs. The Mamani (*Sophora chrysophylla*) tree line extends to about the elevation of the burrows on Mauna Kea. The shortest distance to the sea is 20 miles from this nesting area, compared to five to nine miles for the nesting areas at Haleakala.

Predation, probably the limiting factor in the number of petrels, appears to be at a minimum in the high nesting regions. Cats seem to be a serious predator on Mauna Kea and some sign of them was seen high on Haleakala. They probably would not enter deep petrel burrows and so are unlikely to wipe out populations. Mongooses would not hesitate to enter burrows but, fortunately, they seem to be rare in the high, rocky areas. Goats are abundant on the crater walls of Haleakala, and pigs on Mauna Kea, but their activities would not be likely to affect the petrels. Human predation, although significant in past centuries when petrels were eaten by the Hawaiians, is now negligible.

In addition to the parts of Uau skeletons found in one burrow at Haleakala and at one spot in the central crater area, many Uau bones were found in Hopukane Shelter

Cave, some 10,000 feet high on the south side of Mauna Kea. Artifacts indicate the cave had been used by ancient adze-making and hunting Hawaiians, and many of the bones from at least four Uau appear to have been chewed by man. Dr. Kenneth P. Emory, anthropologist of the Bishop Museum, believes this cave was used at least 150 years ago, testifying to a breeding Uau population of long standing in this area. Emory has heard of the old Hawaiians going to the crater of Haleakala to obtain petrels, so it appears that this breeding area has also long been used.



Fig. 4. Site of petrel burrow at Mauna Kea. Lava flow is old and lichen-covered; Mamani trees are in background.

Although our observations establish the fact that the Dark-rumped Petrel is breeding in at least two areas in the Hawaiian Islands, many more records will be necessary to estimate the size of existing breeding populations. On Haleakala, even though the crater rim is only about 10 miles long, canyons and ridges below it make an extensive potential breeding area. Moreover, tracks of petrels apparently exploring for burrows were found next to lava flows in the floor of the crater. The Haleakala area combined with the great potential breeding area around Mauna Kea suggest that present numbers of the petrels are at least in the hundreds and may be in the thousands.

The senior author would like to acknowledge that his part of this study was carried on under a Bernice P. Bishop Museum Fellowship. Both authors acknowledge the help of the Territorial Division of Fish and Game and of Hawaii National Park.

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THE ANNUAL GONAD AND THYROID CYCLES OF THE ENGLISH SPARROW IN SOUTHERN CALIFORNIA

By JOHN DAVIS and BETTY SCHUCK DAVIS

The annual gonad and thyroid cycles of the English Sparrow (*Passer domesticus*) in southern California were investigated in order to establish their nature in an area of mild winter climate, to provide data for comparison with the annual cycles of this species which have been described from areas subject to lower winter temperatures and greater seasonal change, and to see whether any correlation exists between the gonad and thyroid cycles.

The testis cycle of the English Sparrow has been described from Norman, Oklahoma, from November, 1932, to November, 1933, by Allender (1936a, 1936b) and from Minneapolis-St. Paul, Minnesota, from October, 1932, to March, 1933, by Kirschbaum and Ringoen (1936).

The thyroid cycle of the English Sparrow has been described from several localities. Although there are differences in the findings reported by certain workers, the general pattern in this and other species is one of thyroid activity prior to molt and during the colder months of the year. It has been demonstrated experimentally that the exposure of English Sparrows to low temperature will induce a high level of thyroid activity (D. S. Miller, 1939). Höhn (1950) has reviewed the more important literature on the avian thyroid.

ACKNOWLEDGEMENTS

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MATERIALS AND METHODS

This study is based on the microscopic examination of the testes of 95 male English Sparrows, the thyroids of 91 males and 64 females, and the macroscopic examination of the reproductive tracts of 69 females. These birds were collected from June 3, 1952, to July 15, 1953. Most of them were live-trapped in Pasadena, Los Angeles County, California. All others were caught within six miles of central Pasadena. The testes and thyroids were removed and fixed within a few minutes after each bird was killed. The testes were measured to the nearest 0.5 mm. All birds were skinned and examined for subcutaneous fat deposits and degree of skull ossification. The skins were saved and examined for evidence of molt. The bill color of each male was noted, since Keck (1932) has shown that the bill changes from brown and horn in sexually inactive males to black in sexually active males. The ovary and oviduct of each female were examined, and the presence or absence of a brood patch was noted.

Testes and thyroids were prepared for microscopic examination as follows: after fixation in Bouin's solution and preparation by the dioxane-paraffin method, they were

sectioned at 8μ (a few were sectioned at 10μ) and stained with Harris' hematoxylin and eosin.

In order to indicate the amount of spermatogenic activity showed by the testes examined, the six stages of histologic development outlined for *Passer domesticus* by Bartholomew (1949) were used. These are as follows:

- Stage 1. Resting spermatogonia only.
- Stage 2. Spermatogonia dividing, but only a few spermatocytes present.
- Stage 3. Many spermatocytes present.
- Stage 4. Spermatocytes and spermatids.
- Stage 5. Spermatids and a few spermatozoa.
- Stage 6. Full spermatogenic activity with many spermatozoa.

Center sections of at least one testis from each animal were examined and assigned to one of the foregoing stages.

Thyroid activity was difficult to evaluate because most of the glands examined during this study presented a composite picture, a given center section containing appreciable numbers of follicles which were in active, inactive, and intermediate stages of epithelial development. The same difficulty existed with respect to follicle size. Although the average difference in the size of follicles between an inactive and a highly active gland could be easily perceived (figs. 1 and 2), it was difficult to express this difference quantitatively. The selection of an arbitrary number of follicles to be measured for size would be purely subjective, and in the highly composite thyroids studied here, where even in a very active gland considerable numbers of large follicles exist, the sets of figures derived from such measurements would probably be similar for glands in active, inactive, and intermediate stages of development. It should be further noted that the variability in epithelial development extended even to the follicle level, where within a given follicle, cells of two or three different developmental types often existed side by side (figs. 4, 5).

Since the glands to be studied were of such a heterogeneous nature, it was felt that the state of development of the individual epithelial cells would be the most objective index to use in assaying general thyroid activity. Thus, on the basis of relative cell height, cell configuration, and nuclear configuration, five stages of epithelial development were distinguished, as follows:

- Stage 1. Epithelium very flat ($0.63-1.43\mu$); nucleus flat or crescentic, very darkly staining, in contact with cell membrane (fig. 3).
- Stage 2. Epithelium flat ($2.4-3.3\mu$); nucleus narrowly oval to oval, and in contact with cell membrane (figs. 3 and 4).
- Stage 3. Epithelium moderately flat ($3.8-5.7\mu$); nucleus broadly oval to round and may or may not touch cell membrane (figs. 4 and 5).
- Stage 4. Epithelium cuboidal ($6.65-8.55\mu$); nucleus round, in contact with cell membrane (if at all) at base of cell away from lumen (fig. 5).
- Stage 5. Epithelium columnar or conical, protruding into lumen ($8.55-15.2\mu$); nucleus round and located at base of cell away from lumen (fig. 6).

Cells in stages 1, early 2, late 3, 4, and 5 were easily distinguished; those in late 2 and early 3 were more difficult to distinguish, and a certain amount of subjectivity entered into the method when such cells were encountered. To reduce this subjectivity to a minimum, all classification of cells into stages was done by one person (the junior author). In actual practice, epithelial heights were not measured; the heights are presented merely to describe more exactly the stages present.

Using the foregoing criteria, the index of thyroid activity was determined for center sections of at least one lobe of all thyroids, as follows:

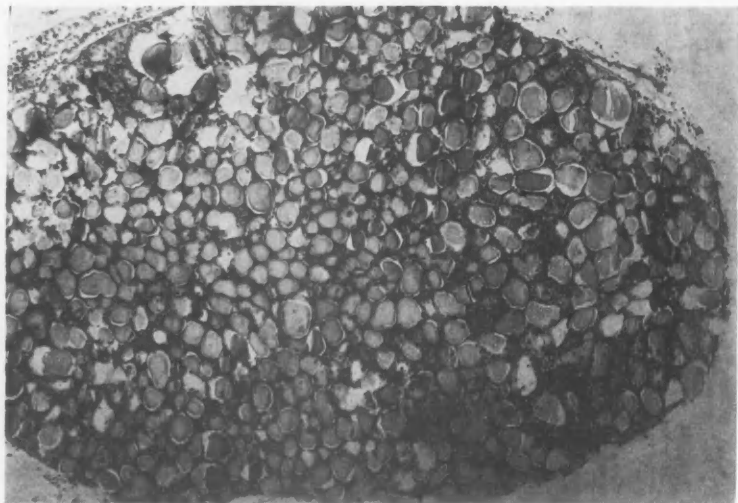


Fig. 1. Cross section of inactive thyroid (index 1.71) from breeding δ , no. 141, May 2, 1953, $\times 162$.

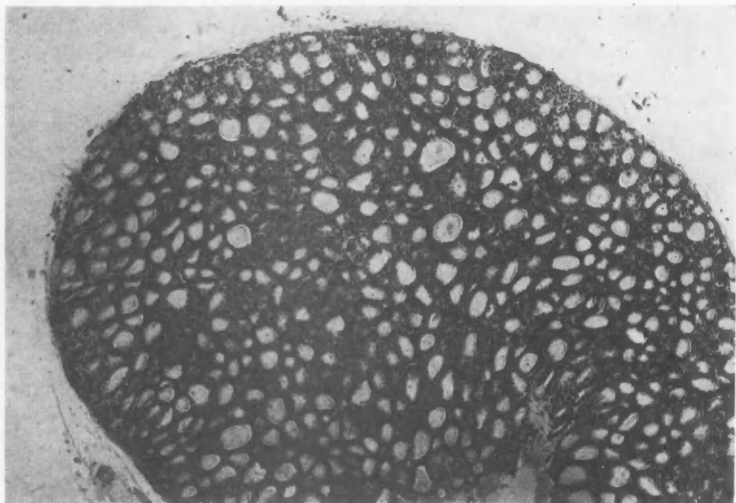


Fig. 2. Cross section of active thyroid (index 3.81) from breeding δ , no. 26, July 7, 1952, $\times 162$.

1. An ocular with a crosshair was oriented so that the hair passed across the middle of a given section. 2. The first and last cells of each follicle, or edge of follicle, intersected by the crosshair were then examined and assigned to one of the epithelial stages previously described. 3. The total number of cells assigned to each stage was then multiplied by the number of that stage (1, 2, 3, 4, or 5), and the figures thus derived were

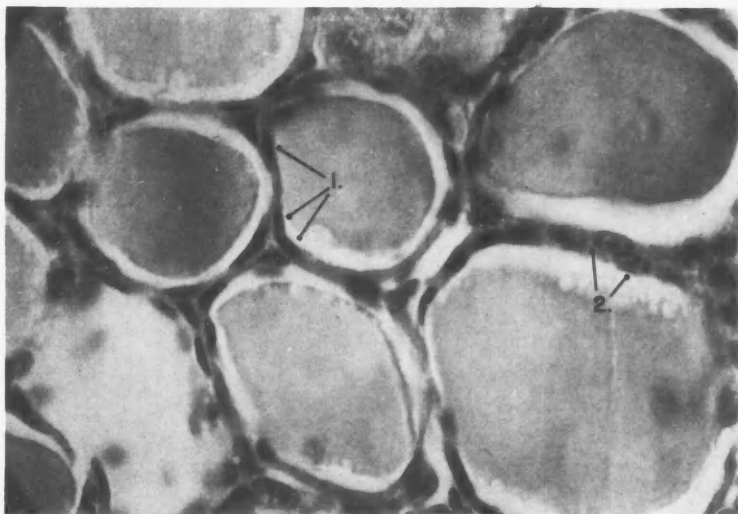


Fig. 3. Follicles in inactive condition, showing developmental stages 1 and 2, from adult ♂, no. 36, August 15, 1952 (index 2.18), $\times 1650$.

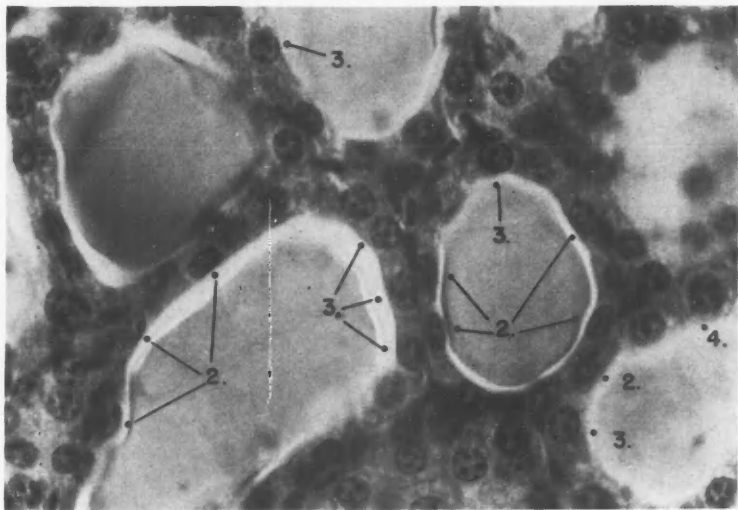


Fig. 4. Follicles in intermediate state of activity, showing developmental stages 2, 3, and 4, from immature ♀, no. 48, October 18, 1952 (index 2.80), $\times 1650$.

added. The sum was then divided by the total number of cells examined, and an index figure for each thyroid was obtained. 4. The foregoing procedures (steps 1-3) were carried out for each of two perpendicular axes crossing the middle of each section. A lapse of over a month's time was allowed between the evaluation of the two axes to

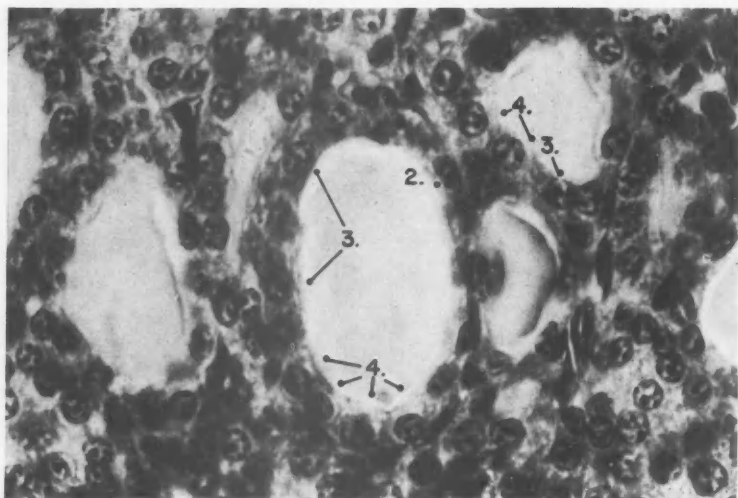


Fig. 5. Follicles in state of moderate activity, showing developmental stages 2, 3, and 4, from breeding ♂, no. 26, July 7, 1952 (index 3.81), $\times 1650$.

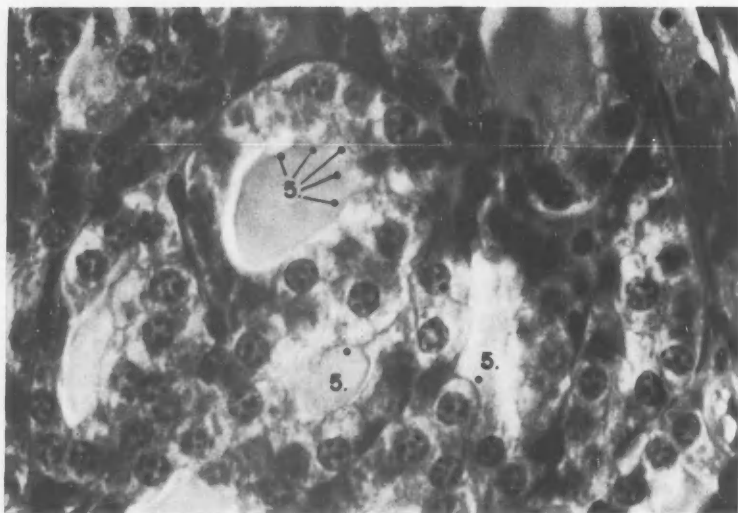


Fig. 6. Follicles in state of high activity, showing developmental stage 5, from different area of same section illustrated in Figure 5, $\times 1650$.

avoid chance of bias. The two sets of figures (as derived in step 3) were then combined and averaged to provide the indices of thyroid activity presented in figure 9.

According to this system of evaluation, a figure of 1 would indicate a thyroid that is wholly inactive, and a figure of 5, one that is completely active. Left and right thyroid

lobes were not separated in this study, but a check on possible discrepancies between lobes, based on the examination of both lobes from 18 thyroids, indicated that no significant discrepancies occurred. It is thoroughly realized that a true determination of thyroid activity would depend on many more factors and more complicated techniques than those employed here. We believe, however, that the method used, although admittedly somewhat subjective, does serve to indicate periods of relative activity and inactivity in the thyroid cycle of the English Sparrow.

THE GONAD CYCLES

The male cycle (fig. 7).—Between June 3 and September 7, 1952, the testis cycle was based entirely on birds with fully ossified skulls. The testes of 12 males taken be-

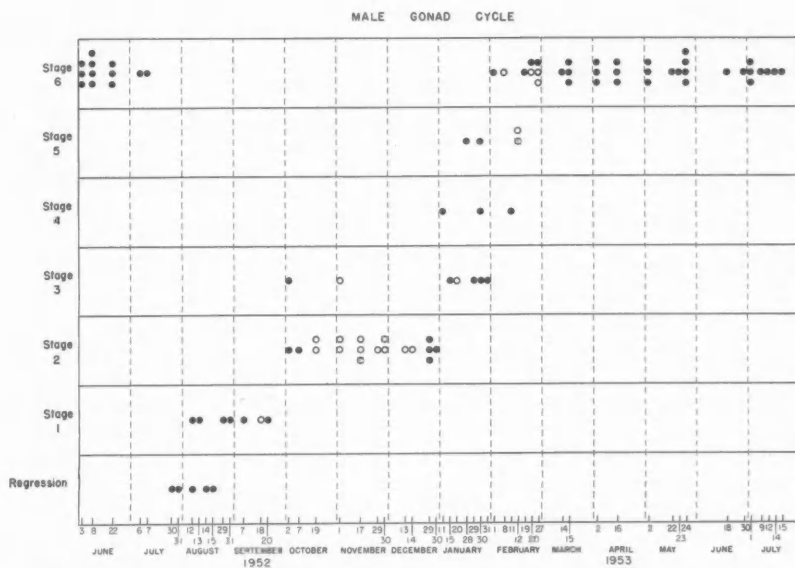


Fig. 7. Testis cycle of *Passer domesticus* at Pasadena, California, from June 3, 1952, to July 15, 1953. Dots represent individuals with completely ossified skulls; circles, individuals with partly ossified skulls.

tween June 3 and July 7 were in breeding condition (stage 6). Free spermatozoa were noted in the lumina of the tubules of most of these testes. The testes of a male trapped on July 30 were regressing from breeding condition. Two or more rows of spermatogonia were present in the tubules, but later stages were absent and the lumina were occluded. The tubules were small, the intertubular "connective tissue" elements were prominent, and the tunica albuginea was very thick. The testes of a male taken on July 31 were in an earlier stage of regression. In some tubules the spermatozoa were no longer aggregated in bundles, and the lumina were filled with free spermatozoa and degenerating cells. Of the testes of five birds trapped between August 12 and 15, three were regressing from breeding condition, and two had reached the fall inactive condi-

tion (stage 1) characterized by small tubules with one or two rows of resting spermatogonia regularly arranged around the basement membrane, prominent intertubular elements, and a very thick tunica albuginea. The testes of four adults and one immature trapped between August 29 and September 20 were also in stage 1. Leydig cells were present, but rare, in the testes of four of the seven birds in stage 1. The testes of three adults trapped between October 2 and 7 show definite signs of a recrudescence of gonadal activity. The testes of single adults trapped on October 2 and 7 were in stage 2. The spermatogonia had proliferated and were arranged irregularly, some having pushed toward the centers of the tubules. Occasional primary spermatocytes were present. A second adult caught on October 2 had testes in stage 3, with primary spermatocytes common. Leydig cells were fairly common in the testes of all three birds. This recrudescence corresponds to that reported by Riley (1937) for the English Sparrow in Iowa.

Between October 19 and December 14 the testis cycle was based entirely on immature birds with partly ossified skulls. The testes of 12 out of 13 males trapped between these dates were in stage 2. They were small, ranging from 1.0 to 2.5 mm. in greatest diameter. The testes of a single male trapped on November 1 were in stage 3. There was some variation in the testes in stage 2, since primary spermatocytes were more common in some than in others. However, the spermatogonia in all were arranged in irregular fashion about the periphery of the tubules and extended farther toward the center than in testes in stage 1. Leydig cells were present in all, ranging from rare to fairly common. Thus, in no individual were the testes in the state of complete tubular inactivity characteristic of stage 1. It is probable that there was an upswing in gonadal activity in the immatures in October and November, since the testes of a single immature trapped on September 18 were in stage 1. This upswing would account for the fact that the testes of immatures caught during the fall were in stage 2. The fact that testes taken as late as December 14 were also in this stage of activity indicates that the fall upswing was not followed by regression to the inactive state. The bill colors of the immatures trapped between October 19 and December 14 indicate that the testes of these birds were somewhat active. The bills of seven ranged from gray to dark gray, two were grayish brown, three were dark brown, and only one was the light brown color indicative of sexual inactivity.

By the end of December, skull ossification was complete in most immatures, and the skulls of these birds could not be distinguished from those of adults. Therefore, after December 29 only birds with partly ossified skulls were classed as immature.

The testes of four males trapped on December 29 and 30 were in stage 2. There was a marked increase in gonadal activity between the end of December and the middle of January. The testes of a male trapped on January 11, 1953, were in stage 4, a few spermatids being present. The left testis of this bird measured 5×3.5 mm., the right 4×4 mm. This was a sharp increase in dimensions over testes taken from October through December, which ranged between 1.0 and 2.5 mm. in greatest diameter. The testes of single males trapped on January 15 and 20 were in stage 3. The length of the left testes of these birds was 3.5 and 3.0 mm., respectively. The testes of a male trapped on January 28 were in stage 5, with some spermatids transforming into spermatozoa. The left testis measured 7×5 mm., the right 6×5 mm. The testes of five males trapped between January 29 and 31 were in stages 3, 4, and 5. The testes of a male trapped on February 1 were in early stage 6. Spermatozoa were abundant, mainly aggregated into bundles. Bundles were still being formed in some tubules. Free spermatozoa were present in the lumina of some tubules. The left testis measured 8×5 mm., the right testis 6×6 mm. An immature male trapped on February 8 had testes in stage 6. Each testis measured

7×6 mm. No spermatozoa were present in the lumina. The testes of three males trapped on February 11 and 12 were in stages 4 and 5. Two of these birds were immature. From February 19 to the end of the study on July 15, the testes of all males were in breeding condition (stage 6).

Davis (1953) reported trapping three sexually mature juvenal male English Sparrows in the Pasadena area on June 21, June 22, and July 6, 1952. These birds were characterized by incomplete skull ossification, predominantly juvenal plumage, testes which were histologically in stage 6, and dark bill coloration. Three additional sexually mature juveniles were trapped in 1953, on June 18, June 22, and July 15. Skull ossification was incomplete in all three and the plumage was predominantly juvenal, although the postjuvenal molt was under way in all. The bills of the two birds trapped in June were black. The bill of the bird taken in July was dark brown above and horn color tipped with dark brown below. The testes of all were in stage 6. Leydig cells were present, the tubules were large, and the tunica albuginea was thin and fibrous. These testes were indistinguishable from those of breeding adults. The occurrence of a few sexually precocious male juveniles is apparently regular from year to year in the Pasadena area.

The female cycle (fig. 8).—The female reproductive cycle was based on macroscopic observation only. The criteria used were follicular enlargement, increase in the size of the oviduct, and the presence or absence of a brood patch. Eleven females with fully ossified skulls, trapped between June 3 and July 9, 1952, were in breeding condition. All had brood patches and expanded oviducts. Three had large, yolky ova at the proximal end of the oviduct. Five females trapped between August 8 and September 27 were

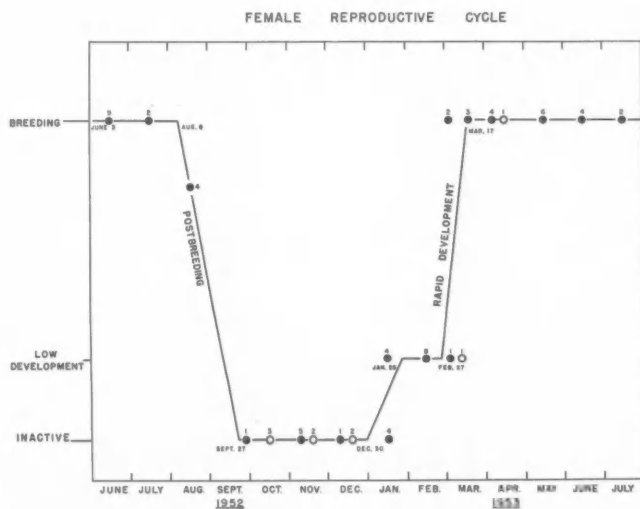


Fig. 8. Female reproductive cycle of *Passer domesticus* at Pasadena, California, from June 3, 1952, to July 15, 1953. Numbers over dots represent total numbers of birds with ossified skulls taken each month in the various stages of reproductive activity; numbers over circles represent the data for birds with partly ossified skulls. Dates on chart refer to approximate times of changes in the reproductive cycle.

in postbreeding condition. A female taken on August 29 had a few ensheathed replacement feathers in the brood patch. Females taken between September 27 and December 30 were sexually inactive. The ovaries of these birds appeared almost homogeneous, with all follicles small and about the same size. Two females were trapped on January 1, 1953. The ovary of one was inactive, but a few slightly enlarged follicles were present in the ovary of the other. The ovaries of females taken between January 1 and 28 were either inactive or in a stage of low development as evidenced by the slight enlargement of some follicles. Between February 1 and 27 enlarged follicles were present in the ovaries of all females examined. Three of eight birds collected during this period had noticeably enlarged oviducts. Between February 27 and March 17 there was a rapid development of the reproductive tract to breeding condition. Of three females trapped on March 14, two were in breeding condition. Each had a brood patch and greatly enlarged oviduct. The ovary of one had two large, yolky ova measuring 7 and 8 mm. in greatest diameter, and a large, soft egg was present in the terminus of the oviduct. The ovary of the other had many enlarged follicles and a yolky ovum 4 mm. long. The ovary of a bird killed on March 16 was still in a low stage of development. Of three birds trapped on March 17, two were ready to lay, and the ovary of the third contained two yolky ova 7 and 9 mm. long. All the females taken after March 17 were in breeding condition.

The females thus progressed from a low stage of ovarian development to breeding condition during a period of 18 days. This rapid development is similar to that described for other passerines (for example, *Sturnus vulgaris*, Bissonnette and Zujko, 1936; *Junco oreganus*, Wolfson, 1942).

THE THYROID CYCLE

In working out the thyroid cycle, immatures and adults were not separated. During the fall and early winter, when these age groups can be distinguished on the basis of degree of skull ossification, the males in each age group are showing signs of slight gonadal upswing and all females are sexually inactive. Therefore the thyroids in each age group are subjected to the same influences.

The thyroids of the males showed a steady rise in activity from June 3 to July 30, 1952. This rise in activity apparently represented the premolt activity period of the thyroid, since molt in the population studied extended from August 13 to September 18. Between July 31 and August 29 there was considerable variation in thyroid activity. This did not seem to be correlated with the stage of molt of individual birds. Two males taken on August 12 had not started the molt, but their thyroids were active. A male taken on August 13 had replaced the inner primaries on each side, and the thyroid of this bird was also active. Single males trapped on August 14 and 15 had not started the molt, and their thyroids were inactive. A male taken on August 29 was in the terminal stage of molt, and the thyroid was active. Apparently there was considerable individual variation in the rate of regression from the premolt level of activity. During September thyroid activity was noticeably below the premolt level.

From October 2 to November 1 there was a steady rise in thyroid activity. This rise coincided with the first noticeable drop in air temperatures from the high temperatures of the preceding three months which had reached a peak in September (fig. 10). However, in November there was a decrease in thyroid activity even though air temperatures continued to drop during that month. Although the temperatures dropped even lower than those in October, apparently they never became low enough to sustain the higher level of thyroid activity which had been induced in October as a response to the initial lowering of air temperatures. The fact that the only marked deposition of subcutaneous

fat in males that occurred during this study took place between October 19 and November 30 would indicate that the relatively mild temperatures of that period reduced the necessity for high thyroid activity. Of 11 males trapped between these dates, four had fat deposits which ranged from moderately heavy to heavy. This suggests that the intake of productive energy exceeded the demand for such energy and the excess was stored as fat. In October and November energy was not expended in reproductive activity, and temperatures were not low enough to demand increased utilization of energy for the maintenance of body temperature. The situation seems similar to the one hypothesized by Kendeigh (1949) to account for the deposition of fat in migratory birds prior to the spring migration. The fact that the major period of fat deposition in females occurred during the same period further supports the explanation just suggested. Of ten females trapped between October 19 and November 29, five had moderately heavy to heavy fat deposits. The only other females with appreciable fat deposits were single birds trapped on February 21 and March 17. Since fat was deposited in both sexes at a time when the testes were somewhat active but the ovaries were completely inactive, it would appear that accumulation of fat was not correlated with gonadal activity.

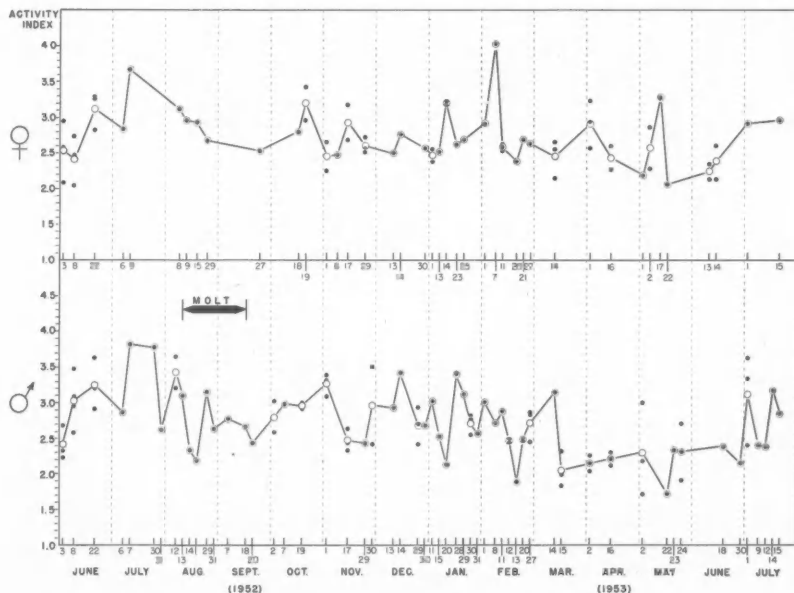


Fig. 9. Thyroid cycles of male and female *Passer domesticus* at Pasadena, California, from June 3, 1952, to July 15, 1953. Dots represent values for individual birds; circles represent average values when more than one individual was taken on the same day; where average value and an individual value coincide, a dot appears within the circle.

Between November 30, 1952, and March 15, 1953, thyroid activity was subject to a great amount of individual variation in the males. The abrupt peaks and lows are not explicable on the basis of external temperatures. The most important consideration is that the winter of 1952-1953 at Pasadena was unusually mild. Weekly temperatures

between November 30 and March 15, based on averages of daily maxima and minima, averaged 55.5°F . The lowest temperature during this period was 33° . On 26 days the maxima were 75° or above. On 42 days the minima were 45° or above. It seems likely that the intensity of the stimulus provided by air temperature was never maintained at a level high enough, and for a sufficiently long period, to cause a sustained rise in thy-

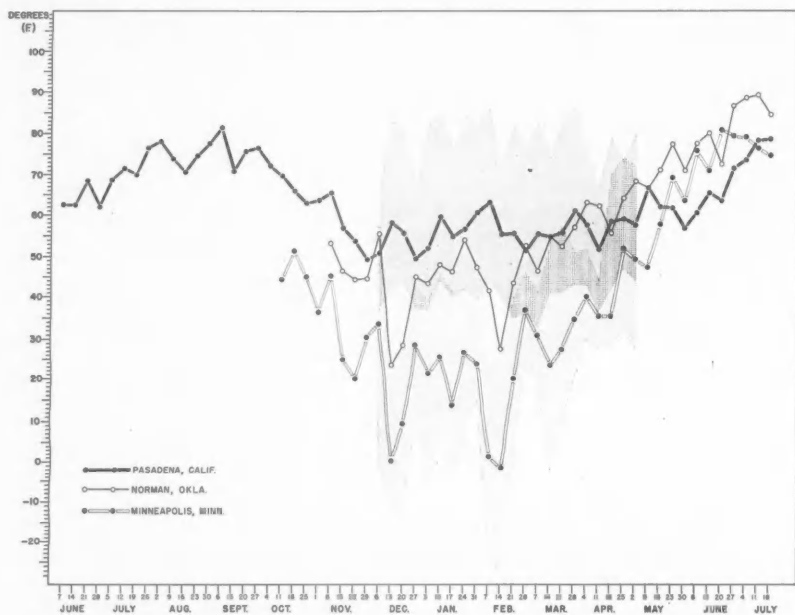


Fig. 10. Averages of daily maximum and minimum temperatures for one-week periods at Pasadena, California (June, 1952, to July, 1953), Norman, Oklahoma (November, 1932, to July, 1933), and Minneapolis, Minnesota (October, 1932, to July, 1933). Medium stippling represents total weekly temperature ranges at Pasadena; light stippling represents total weekly temperature ranges at Minneapolis; dark stippling occurs at areas of temperature overlap. Pasadena temperatures from Pasadena Water Department records; Norman and Minneapolis temperatures from U. S. Dept. Agr., Weather Bureau, Climatological Data.

roid activity in the entire male population, or even in an appreciable part of it. In short, with the environmental stimulus so weak, there was probably an expression of the individual physiological variability to be expected in a series of birds of unknown origin and past history. Between March 15 and June 30 thyroid activity was at a noticeably low level. Between July 1 and 15 there was again considerable variation, but the level of thyroid activity during this period was definitely above that noted during the preceding three and one-half months. This apparently represented the onset of premolt thyroid activity in 1953.

The study of the female thyroid cycle was less satisfactory since only 64 birds were examined as against 91 males. In the females there was an almost steady rise in thyroid activity between June 3 and July 9, 1952, apparently representing the premolt activity. Between July 9 and September 27 there was a gradual, steady drop-off in activity, fol-

lowed by a gradual rise until October 19. Between October 19 and May 22 the cycle was variable, although generally within narrower limits than in the male cycle. Between May 22 and July 15 there was a steady rise in thyroid activity, probably representing the premolt activity of 1953. A summary of the male and female thyroid cycles is presented in figure 9.

DISCUSSION

The gonad cycles.—Blanchard (1941) and Blanchard and Erickson (1949), working with various races of the White-crowned Sparrow (*Zonotrichia leucophrys*) described a stage of complete testis inactivity in which the tubules were wholly inactive and Leydig cells were absent from the intertubular tissue. This condition, termed stage 1, occurred during the fall and early winter. It was followed in late winter by stage 2, in which the tubules were still inactive but occasional Leydig cells appeared in the intertubular tissue. Wolfson (1942) did not recognize a stage in the testis cycle of the Oregon Junco (*Junco oreganus*) corresponding to stage 1 of Blanchard. He noted that when the tubules were inactive and the size of the testis was at a minimum the intertubular tissue contained two types of cells, one of which he regarded as interstitial cells. More recently A. H. Miller (1954), working with *Zonotrichia leucophrys* and with the Golden-crowned Sparrow (*Zonotrichia coronata*), reported that testes of these species examined during the refractory period were rarely found without either Leydig cells, or somewhat enlarged and rounded cells that might be developing Leydig cells. Our material supports the findings of Wolfson and Miller. As mentioned previously, four of seven testes of *Passer domesticus* in stage 1 taken between August 12 and September 20 showed occasional Leydig cells in the intertubular tissue. In our material we could make no clear-cut distinction between stages corresponding to stages 1 and 2 of Blanchard.

Wolfson (*op. cit.*) recognized five histologic stages in testis development in *Junco oreganus*. Our stages 1 to 3 correspond to his stages of similar designation. His stage 4 includes our stages 4 and 5. He pointed out that between stage 3 and breeding condition events occur with such rapidity that it is not feasible to recognize more than one stage during this period. Our stages 4 and 5 were the most difficult to delimit. However, they were kept apart to show in more detail the relative positions of individuals in the gonad cycle and the amount of variation in testes taken on the same day. The fact that we recognize six stages in *Passer domesticus* does not imply any marked difference between the testis cycles of this species and *Junco oreganus* but merely reflects a difference on the part of the investigators in the arbitrary and subjective breakdown of a rapid and continuous process.

The testis cycle at Pasadena differed in several respects from the cycles of the English Sparrow described from Norman, Oklahoma, by Allender (1936a, 1936b) and from Minneapolis-St. Paul, Minnesota, by Kirschbaum and Ringoen (1936). Allender (1936b) reported the absence of interstitial cells in testes in stage 1, whereas we found such cells present in more than half of the testes in this stage. She stated that when the tubules enlarge and spermatogenesis is under way "very few interstitial cells are present and for a short time only." In our material these cells are present in all stages from 1 to 6. She also stated that "no spermatozoa were found free in the lumen at any time" in testes in breeding condition. This is in marked contrast to our findings, since the majority of testes in breeding condition had free spermatozoa in the lumina. Neither Allender (*op. cit.*) nor Kirschbaum and Ringoen (1936) reported any signs of autumnal gonadal activity in adults or first-year birds. We noted a definite upswing in gonadal activity in both age groups in October and early November, following which the testes failed to regress to the inactive condition of the late summer and early fall. Our findings

agree more closely with those of Riley (1937) who reported increased gonadal activity in males of this species in Iowa during November, soon followed by regression to the completely inactive state. Marshall (cited in Summers-Smith, 1954) reported that gonadal development had begun in eight male *Passer domesticus* taken in late October and early November in southern England. Daanje (cited in Summers-Smith, 1954) in The Netherlands and Summers-Smith (*op. cit.*) in England noted that communal displays involving a single unresponsive female and two or more males with active testes decreased in frequency in the late summer and became more frequent in October and November. These observations suggest increased gonadal activity in the males during these months. Allender (1936a) reported that at Norman both sexes came into breeding condition at about the same time, March 1. At Pasadena the males reached breeding condition almost a month ahead of the females (February 19 versus March 17). At Minneapolis-St. Paul, Kirchbaum and Ringoen (1936) reported that the males reached breeding condition at the end of March. At this time large follicles were present in the ovary. The oviducts were hypertrophied but "not until April, however, do they appear ready to receive discharged egg cells." A lag in the female cycle is thus implied, although it is not possible to estimate its magnitude.

The possible influence of the thyroid cycle on the testis cycle.—The males reached breeding condition at Pasadena on February 19, at Norman, Oklahoma, on March 1, and at Minneapolis-St. Paul, Minnesota, on or about March 31. Pasadena lies at about latitude $34^{\circ} 05'$, Norman at $35^{\circ} 10'$, and Minneapolis-St. Paul at 45° . Thus the differences in the timing of testis development at the three localities were roughly proportional to the differences in latitude. Between Pasadena and Norman there is a difference of 10 days between the testis cycles and a difference of $1^{\circ} 05'$ in latitude, between Norman and Minneapolis-St. Paul, 30 days and $9^{\circ} 50'$, and between Pasadena and Minneapolis-St. Paul, 40 days and $10^{\circ} 55'$. Since the daylength cycle is retarded from south to north before March 20, a partial correlation may be made between daylength and gonadal activity. The latitudinal difference between Pasadena and Norman is so slight that the daylength cycles would be about the same at each locality, and difference in daylength could account for only a small part of the total difference between the testis cycles. However, there is a marked difference between the daylength cycles at Pasadena and Minneapolis-St. Paul, but it is difficult to estimate the amount of this difference as the daylength cycles are of different configuration.

In order to arrive at a standard for comparison, the ten-hour day, based on civil sunrise to civil sunset, may be used as an arbitrary point in the daylength cycle. The ten-hour day is reached at Pasadena on January 12, and at Minneapolis-St. Paul on February 6. This represents a difference of 25 days. To give some idea of the events in the testis cycle occurring at each locality near these dates, a single male taken at Pasadena on January 11 was in stage 4, and one taken on January 15 was in stage 3. At Minneapolis-St. Paul, some testes taken on February 12 were in transition from stage 1 to stage 2. Other testes taken on the same date were in stage 1 with some proliferation of spermatogonia. Daylength is the same at both localities on March 20. At this time the males at Pasadena had been in stage 6 for a month. The testes of males collected at Minneapolis-St. Paul on March 19 showed metamorphosing spermatids and a few spermatozoa (stage 5). "However, a testis with great numbers of mature spermatozoa is not observed until March 26" and not all testes were producing mature spermatozoa at that date (Kirchbaum and Ringoen, 1936).

Again using the ten-hour day as a reference point, the males at Pasadena came into breeding condition on February 19, 38 days after this daylength had been reached.

At Minneapolis-St. Paul they reached breeding condition on March 31, 53 days after the ten-hour day had been reached. Daylength at Pasadena on February 19, when the males reached breeding condition, was 11 hours and 3 minutes. Daylength at Minneapolis-St. Paul on March 31, when the males there reached breeding condition, was 12 hours and 41 minutes. It would appear that some factors other than the difference in the daylength cycles were retarding the testis cycle at Minneapolis-St. Paul. Some factor other than daylength must definitely have been involved in delaying the cycle at Norman by ten days, since the latitudinal difference between Pasadena and Norman is so slight.

Using the ten-hour day as a reference point, 25 of the total difference of 40 days between the testis cycles at Pasadena and Minneapolis-St. Paul may be accounted for on the basis of daylength. This leaves a difference of 15 days to be accounted for. As pointed out previously, it took the males at Pasadena 38 days to reach breeding condition after the ten-hour day had been reached, whereas it took the males at Minneapolis-St. Paul 53 days after this point in the daylength cycle. This again is a difference of 15 days. As regards the difference between the testis cycles at Pasadena and Norman, it may be assumed that the entire difference of ten days is independent of daylength since the two localities are at approximately the same latitude. Thus there is a greater proportional difference between the cycles at Pasadena and Minneapolis-St. Paul than between the cycles at Pasadena and Norman, 15 versus 10 days. Since the differences of 10 and 15 days in the testis cycles are apparently independent of daylength, another environmental factor must be proposed to account for them.

When the temperatures at the three localities are plotted (fig. 10), it may be seen that during the critical months of the testis cycle (January, February, and March), temperatures at Norman are lower than those at Pasadena and they are considerably lower at Minneapolis than at either of the other localities. A correlation may then be made between the differences in temperature and the differences in the timing of the three testis cycles. The retarding effect of low temperature on spermatogenic activity has been reported in several species of birds. For example, Marshall (1951) collected the testes of four species of passerines common at Oxford, England, in mid-March, 1947, during one of the coldest winters on record in the British Isles. Testes of the same species were collected at precisely the same locality exactly one year later, during an unusually mild winter. The testes collected in 1947 were in a low stage of development, whereas those collected in 1948 were far advanced. Blanchard (1941) noted a high correlation between temperature and variations in the timing of the testis cycle in a population of *Zonotrichia leucophrys nuttalli*, a resident form, studied at Berkeley, California, over a five-year period. It seems obvious that low external temperatures must have affected some aspect of the physiology of these birds in such a way that spermatogenic activity was retarded.

The experimental induction of high thyroid activity in *Passer domesticus*, by the exposure of individuals to low temperatures (D. S. Miller, 1939), and the fact that thyroid activity increases in wild birds during the cold months of the year (see Höhn, 1950), at once suggests that the thyroid may be involved in the effect of low temperatures on the gonad cycle. The thyroids of the sparrows caught at Pasadena during the mild winter of 1952-1953 showed great individual variation from January to mid-March, and at no time during this critical period in the testis cycle was there a prolonged period of high thyroid activity. Kirschbaum and Ringoen did not examine the thyroids of *Passer domesticus* at Minneapolis-St. Paul, but in view of the far lower winter temperatures at that locality it seems likely that the thyroids of their sparrows would be more active

than the thyroids of the sparrows taken at Pasadena. Winter temperatures were higher at Norman than at Minneapolis, but averaged 9°F. lower than the temperatures at Pasadena during January, February, and March. During these months, it seems possible that the thyroids of the birds at Norman would be somewhat more active than those of the birds trapped at Pasadena and less active than those of the birds taken at Minneapolis-St. Paul. If this be true, the increase in postulated thyroid function from Pasadena to Norman and from Norman to Minneapolis-St. Paul would correlate with the otherwise unexplained differences of ten days between the testis cycles at Pasadena and Norman, and 15 days between these cycles at Pasadena and Minneapolis-St. Paul.

It is here suggested, therefore, that thyroid function, as influenced by winter temperature, may account, at least in part, for temporal differences in the testis cycles of populations of the same species subjected to different winter temperatures, whether at one locality from year to year, or at different localities within the same year. There are two ways in which thyroid function might affect the testis cycle. First, the thyroids and the testes are both controlled by hormones of the anterior pituitary. It is possible that the thyrotrophic and gonadotrophic functions of the pituitary are antagonistic. If this be so, the pituitary is subjected to two environmental stimuli during the late winter that are of major importance in this regard. One is external temperature, inducing thyrotrophic activity, and the other is increasing daylength, inducing gonadotrophic activity. With relatively high winter temperatures, as at Pasadena, the thyrotrophic function of the pituitary would be minimized and gonadotrophic function would be induced in response to the daylength cycle, unhampered by thyrotrophic activity. The reverse would be true in the Minneapolis-St. Paul area, where a high level of thyrotrophic function would be induced by low winter temperatures, and gonadotrophic function would be minimized. An intermediate situation would be found at Norman. Second, it is possible that the high level of thyroxin resulting from high and prolonged thyroid activity, maintained by a lengthy period of low winter temperatures, would in itself have a depressant effect on spermatogenic activity.

It seems likely that the concept of the testis cycle, traditionally thought of in terms of daylength-anterior pituitary-testes, represents an oversimplification. It does not seem possible to divorce the anterior pituitary and the testes from the rest of the endocrine system, nor does it seem possible to divorce daylength from the myriad of other environmental factors which are of utmost importance to birds living under natural conditions. It is hoped that critical experimental work will in the future assess the effects of low temperatures and of such organs as the thyroid and adrenals on the testis cycle.

It seems obvious that the three testis cycles discussed in this paper were controlled by factors other than an inherent annual rhythm. If an inherent, genetically controlled, annual rhythm were invoked to account for the differences in the timing of the three cycles, we would have to assume that each of the three populations concerned differed genetically from the other two, and that we are dealing with three physiological subspecies. However, *Passer domesticus* was introduced into the United States less than 100 years ago, and has subsequently invaded nearly all parts of the country, flourishing over a wide range of environmental conditions. It is inconceivable that this, or any other avian species, should have evolved within such a short period of time a plethora of populations, each adapted by a genetically controlled inherent annual rhythm to the conditions present within its range. It seems impossible to escape the conclusion that geographic variation in the testis cycle results from the geographic variation of certain environmental conditions. Once under way, from whatever cause, the sequence and timing of events in the testis cycle must be regulated by such external factors as daylength and temperature, to name only two.

The timing of breeding.—At Pasadena the actual onset of breeding occurred about one month after the males had reached breeding condition. At the time that the testes were producing mature spermatozoa, ovarian development was still slight. The breeding time was therefore established for this population by the ovarian cycle, not by the testis cycle. The factors influencing the ovarian cycle in birds are not well understood. Summers-Smith (1954) is of the opinion that communal displays in which several male English Sparrows in breeding condition pursue a non-responsive female may be of importance in bringing the female into breeding condition. We have no evidence of this phenomenon and its effect on the females, but it seems likely that the changes in male behavior resulting from gonadal activity at a time when the female reproductive tract is almost inactive are important as a stimulus to the female cycle in this species.

The finding of Allender (1936a) on *Passer domesticus* at Norman indicate that there may be some variation among populations in the temporal difference between the male and female cycles. She reported that at Norman both sexes came into breeding condition at the same time, about March 1. This was based on histological examination of testes, the time of mating, building, and incubating in the population, and the report of week-old young at Norman on March 20 by Nice (1931).

The importance of the female cycle to the timing of actual breeding in a population of birds cannot be overemphasized. Marshall (1951) noted, in his observations of passerines at Oxford, previously discussed, that although the testis cycles of the four species investigated during the severe winter of 1947 were noticeably retarded, "the hard winter was followed by an abnormally bright spell (after the collection date)" and "the surviving birds of at least three species bred at about the normal time!" He felt that unless some dietary factor was involved, sunshine and temperature must have been especially important in the timing of the cycle. An alternative explanation is that the breeding times of these three species were set by the ovarian, rather than by the testis, cycle, and any temporal disparity between the male and female cycles was probably cut down or obliterated by the retardation of the male cycle. In this same paper Marshall cites several examples of the influence of the ovarian cycle in delaying the timing of breeding in populations of several species of birds in which the males were in breeding condition. The timing of breeding of *Passer domesticus* at Pasadena was evidently regulated in the same fashion.

SUMMARY

The gonad and thyroid cycles of *Passer domesticus* were established for the population at Pasadena, California, from June 3, 1952, to July 15, 1953.

The males were in breeding condition in June and early July, 1952, and regressed to an inactive gonadal state in the late summer and early fall. An upswing in gonadal activity occurred in October and November, followed by incomplete regression. Increased spermatogenic activity started in January, 1953, and the males reached breeding condition by February 19, 1953.

The females were in breeding condition in June and early July, 1952. They were in postbreeding condition from early August to late September. The ovary was completely inactive from the end of September to early January, 1953. A low stage of ovarian development was noted from January to the end of February. Rapid development of the reproductive tract took place between the end of February and the middle of March, and the females reached breeding condition by March 17, 1953.

The thyroid cycle was similar in the two sexes. The thyroids were active prior to the onset of molt in 1952 and 1953. Thyroid activity was highly variable during the winter months. The absence of a prolonged period of high thyroid activity in winter was probably the result of the mildness of the winter of 1952–1953 at Pasadena.

In comparison with the testis cycles of this species described from Norman, Oklahoma, and Minneapolis-St. Paul, Minnesota, the males at Pasadena reached breeding condition 10 days before the males at Norman and 40 days before the males at Minneapolis-St. Paul. These differences cannot be explained solely on the basis of the differences in the daylength cycles occurring at each locality.

Winter temperatures at Pasadena were relatively high, those at Norman lower, and those at Minneapolis-St. Paul even lower. There is a correlation between winter temperature and the time at which the males at the three localities reached breeding condition.

Since low temperatures induce high thyroid activity in the English Sparrow, it is suggested that part of the difference in the timing of the testis cycles at the three localities might be the result of interference of the temperature-pituitary-thyroid cycle with the daylength-pituitary-testis cycle. This might result from a possible antagonism of the thyrotropic and gonadotrophic functions of the pituitary, or from the high level of thyroxin maintained by thyroids which were highly active over a prolonged period as a result of low winter temperatures.

Since the males at Pasadena came into breeding condition one month earlier than the females, the time of actual breeding in the population at Pasadena was set by the ovarian rather than by the testis cycle.

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SOCIAL ORGANIZATION AND BEHAVIOR IN A FLOCK OF CAPTIVE,
NONBREEDING RED CROSSBILLS

By HARRISON B. TORDOFF

Analyses of flock organization in social birds have received much attention and have advanced knowledge of the behavior of animals in general. Although social organization has been observed in many kinds of birds, studies have been concentrated on a few species. Notable among these have been domestic chickens, *Gallus* (literature reviewed by Guhl, 1953), pigeons, *Columba livia* (Masure and Allee, 1934a), and shell-parakeets, *Melopsittacus undulatus* (Masure and Allee, 1934b). Within the Passeriformes, few social structures have been studied in detail. One exception is the study by Shoemaker (1939) of social hierarchy in the Canary (*Serinus canarius*). Shoemaker's results are especially important to the studies reported herein because both the Canary and the Red Crossbill (*Loxia curvirostra*) are members of the same subfamily of finches, the Carduelinae. Comparisons between the two species, therefore, should be instructive.

In 1953 at Lawrence, Douglas County, Kansas, Red Crossbills were first reported on November 5, when James S. Findley saw one male and approximately four females on the campus of the University of Kansas. The same flock, presumably, remained on the campus for a week and then moved three-fourths of a mile to some Scotch pines (*Pinus sylvestris*) at the residence of Theodore G. Metcalf. By late November, the flock numbered fourteen individuals—six males and eight females, not counting two males collected on November 12 and 13. On November 30, a live male with a broken right wing was obtained. Using this male as a decoy and hemp seeds as bait, I trapped two females on December 12 and then used the females as decoys and trapped the remainder of the flock in the period from December 18 to 20. All birds trapped, except one, are referable to *Loxia curvirostra benti*; the exception is an immature male which seems to be *L. c. stricklandi* (wing, 97 mm.; tail, 56; culmen, 20.8; depth of bill, 11.7). This male is orangish-yellow with a very few scattered reddish feathers; the other males at the time of trapping were rose-red. Although the male *stricklandi* was killed by accident on December 27, I observed it long enough to note some interesting differences between the two subspecies. In addition to its orangish-yellow color, this male was readily distinguishable from the rest of the birds by its larger size, much more nervous behavior, and especially by its call notes, which were lower pitched and harsher than the calls of the other birds. It would have been interesting to observe the position of this bird in the peck-order.

It seems worth emphasizing that the crossbills studied for this report constituted a nearly complete flock formed under natural conditions in the wild and that they had an "acquaintance" with each other previous to their capture.

METHODS

Trapping.—The birds were trapped in a simple drop-trap, ten inches square and four inches high, made of half-inch hardware cloth. They showed little hesitation in going under this trap. As birds were trapped and added to the cage containing the decoy birds, it became progressively easier to trap the remainder. The last few birds repeatedly started to leave, only to be lured back by the calls of the captives.

Marking.—On December 23, the crossbills were transferred from a small, indoor cage to a larger cage out-of-doors. They were marked with colored bands on December 30, as follows: Males were banded on the left leg only—aluminum ("A" in the discussion that follows), white (W), blue (B), orange (O), green (G). Females were

banded on the right leg only—orange (OR), white (WR), red (RR), tan (TR), green (GR); or on both legs—right orange, left aluminum (OA); right red, left aluminum (RA). Note that the designations for males are single letters, in contrast with the two-lettered designations of the females.

The flock as studied consisted of five of the original eight males and seven of the original eight females. At the time of banding, one female had scabby feet. This bird was liberated to avoid infection of the other crossbills.

Food and housing.—The crossbills were housed in a cage measuring six feet by nine feet by six feet high. The cage was constructed of separate panels, each six feet by three feet, joined together with carriage bolts. The panels were framed by two-by-twos and covered with one-fourth inch mesh hardware cloth. One panel had a door in it. An advantage of a cage of this construction is its adaptability. The cage can be enlarged or made smaller by adding or removing panels. The floor consisted of hardware cloth to exclude burrowing predators while permitting the birds access to vegetation and soil.

Perches and cover in the cage were provided by a Scotch pine four feet tall planted in the cage, by foliage-bearing branches of red cedar (*Juniperus virginiana*), and by sticks placed in various parts of the cage. Roosting boxes, open at the bottom and front and divided into compartments three to four inches wide, were placed along one side of the cage near the top. Water in an open pan and food were available at all times. Through most of the period of observation, the principal food was seeds of hemp (*Cannabis sativa*) and sunflower (*Helianthus annuus*), although piñon (*Pinus edulis*) nuts were also used late in the period. The seeds were available in automatic feeders. Because of the well known propensity in carduelines for eating salt, a small block of mixed salt and minerals was made available. Cuttle bone and grit also were regularly taken.

Methods of observation.—Systematic observations, made inside the cage, totalled 26 hours in the period from December 31, 1953, to March 25, 1954. The presence of the observer in the cage seemed not to affect the behavior of the crossbills, which in captivity are very tame. Casual observations of general behavior more than quadrupled the total time of observation but were not recorded in detail.

Notes were kept of courtship feeding, singing, pre-roosting activities, and other aspects of behavior. Most detailed notes, however, were made of encounters between individuals in which dominance was displayed. The dominance-submission rôles of individuals were recorded for each encounter as follows: $W > B$, where male W dominated male B ; $OA > GR$, etc. This method made possible measurements of aggressiveness, based on frequency of encounters, as well as determination of peck-order. I had no difficulty in deciding which individual was dominant in any encounter. Behavior in this respect was obvious, as is described beyond. A total of 2,144 encounters was recorded.

GENERAL BEHAVIOR

The crossbills became accustomed to confinement in a few days but did not become indifferent to outside stimuli as caged birds sometimes do. They reacted to hawks passing overhead by becoming motionless, peering at the hawk, and giving a single low note which can be described as *tuck, tuck, tuck*. They resumed their normal activities within a minute after the hawk passed from view. Sometimes the hawks were so high as to be scarcely visible to the naked human eye. In the daytime, domestic cats, dogs, cars, airplanes, children, and birds of other species drew little attention from the crossbills. At night cats crawling on the cage caused the birds to fly about in panic but this was soon stopped by trapping the cats. On December 25, an immature male Baltimore Oriole (*Icterus galbula*) was placed in the cage and dominated the crossbills completely. They

seemed afraid of its aggressive advances and it did, in fact, peck some of them. The crossbills reacted to the oriole with threat displays but invariably retreated from it. The oriole was removed from the cage on December 26.

Feeding.—Red Crossbills have been known to eat sunflower seeds in the wild but my birds fed adeptly on them only after considerable practice. At first, the crossbills picked up sunflower seeds, manipulated them in the bill, and dropped them unopened. After a day or two, most of the birds learned to crack the seeds between their tomia but did this much less expertly than Cardinals (*Richmondia cardinalis*). Later the birds were seen to open sunflower seeds in a new manner: the crossbill held the seed against the perch with one or both feet and bit at one end of the seed with the tips of the bill until the husk was pierced. The tips of the mandibles would then be inserted in the crack and pried apart, exposing the kernel to the long, agile tongue. The birds have continued to open sunflower seeds in this way, which is of interest in that it employs the same peculiar lateral separation of the mandibles that is used in opening pine cones.

Pine cones were constantly available in the cage and the crossbills spent hours working on them even after the few seeds were removed. Baily (1953:39) recently described the use of the bill in opening pine cones (there is a large literature on the subject) but my observations do not agree with his. My crossbills simply inserted their bills, with the tips approximately opposing each other, under the cone scales. This necessitates partial opening of the bill; it remains open throughout the operation. The scales are then raised by lateral abduction of the lower mandible, that is, toward the side to which the mandible is deflected; this motion is produced by the powerful, asymmetrically developed muscles on this side of the skull. While the tips of the bill hold the cone scales apart, the tongue is inserted to probe for and remove the seeds.

Regardless of sex in crossbills, the direction of crossing of the bill is approximately evenly divided. In half of the birds, the lower mandible, which deviates more from the midline than the upper, passes to the right of the upper, in the other half, to the left. I was surprised to find that this morphological asymmetry of the bill is correlated with "right- or left-handedness" of the individual bird, at least in its opening of pine cones. When a crossbill feeds on a cone, the long axis of the bird's head is approximately at right angles to the long axis of the cone. The bird orients itself so that the tip of the lower mandible is on the side toward the distal end of the cone. When the bill is inserted beneath a cone scale, the tip of the lower mandible presses toward the central axis of the cone, in the lateral motion described above, while the scale is raised by the essentially stationary tip of the upper mandible. I saw no variation in this.

Known cases of "right- or left-handedness" are rare in birds. Parrots often favor one foot for clutching objects, but no morphological basis for the preference is apparent. In the Wry-billed Plover (*Anarhynchus frontalis*) of New Zealand, the bill is always bent to the right and the species is said to probe under stones, around which the birds run in a clockwise direction. The bill and skull of oyster-catchers (*Haematopus*) are bilaterally asymmetrical as a result of, or perhaps as an adaptation to, their peculiar method of prying invertebrates from rocks, but here again the asymmetry is in the same direction in all individuals (Webster, 1941:177). In Limpkins (*Aramus guarauna*) the bill is slightly bent near the tip but I know of no careful study of the significance of this asymmetry. *Loxops coccinea*, of the Drepaniidae, has slightly crossed mandibles. Nothing is known concerning possible "right- or left-handedness" in this species. Crossbills seem to be the only birds so far studied in this regard in which individuals are either "right- or left-handed," depending on the form of the bill.

Hemp seeds were cracked and shelled between the tomia of the bill. The crossbills

fed also on flowers and seeds from maples and elms which fell on the top of the cage. The crossbills nearly denuded the Scotch pine planted in the cage and regularly stripped the cedar branches put in to provide cover. Bits of pine needles and perhaps also cedar needles were eaten, but most of the "chewing" seemed to result from a compulsion to twist, pry, and bite at objects—almost any objects—with the bill. This urge probably is largely satisfied in the wild by normal feeding on cones. The crossbills reduced branches up to a half-inch in diameter to slivers; they shredded tough pine cones; they chewed the lumber in the cage until the edges were rounded; they pried endlessly in cracks. All these activities seem to keep the tips of the bill from becoming too long—a real possibility in this species with non-occluding mandibles. One male (A) in which the upper mandible reached an abnormal length pried especially vigorously and finally broke three millimeters off the horny tip, thereby restoring it to normal appearance.

As mentioned earlier, salt was continuously available to the crossbills. They picked at the salt block regularly; each bird probably ate some salt every day. Commercial canary foods of various sorts were ignored by the crossbills. The birds were unable to crack the husks on piñon nuts but eagerly ate the nuts when I cracked the husks.

Several times I have seen wild crossbills carry pine cones in their bills. My captives did this to get cones from the ground up to the perches where they pecked at the cones held by means of their feet. Pine cones and other objects carried in flight are held in the bill. Some cones which the crossbills carried weighed 12 grams. This seems to me a remarkable feat since the birds weigh only 30 to 35 grams, the cones are held far from the bird's center of gravity, and many of the flights with cones were almost vertical.

Soon after the crossbills were captured, the prenuptial molt began. It agreed with that described earlier for this species (Tordoff, 1952:202-203) and was completed on schedule; this seemed to me evidence of the general good condition of the birds. Feathers lost accidentally were quickly replaced. One female (RA) replaced two rectrices to full length in 30 days from the time of their accidental loss.

Bathing and sun-bathing.—Red Crossbills are vigorous bathers. Once or twice a week I flooded the ground in the cage with an inch or more of water. The crossbills, at the sight or sound of the running water, while still on the elevated perches, often began to flutter their wings, and otherwise act as though bathing. One of the birds would then fly down to the water and the others would follow. Vigorous bathing would then ensue until the birds were so drenched that they could barely fly; some were forced to crawl up the sides of the cage to the perches. As in most other activities, the crossbills were strongly imitative in their bathing and followed the lead of one or a few birds. Air temperature seemed to have no influence on their readiness to bathe. Dust bathing was not observed, but conditions for dust bathing in the cage were not good.

Sun-bathing in Red Crossbills is highly ritualized and regularly performed. I observed it only in late morning on bright days. A bird, after quietly preening and scratching, would raise its feathers and then, usually with its back to the sun, spread its primaries by extending the wrist. The tail was spread in such a manner that all tail feathers were at least partly exposed to the sun. Then the head was drooped and so turned that the sun's rays shone directly into one eye, the bird now appearing to be staring up and back over its shoulder. Finally, the bill was opened in such a way that the tips were about opposite each other, thus exposing the tongue, the lining of the mouth, and one side and base of the bill to the sun. The bird would then sit motionless for up to four or five minutes, staring with wide open eye into the sun. Some birds, at least, blinked the eyelids at intervals of a second or two. The "objective" clearly was to expose the greatest possible amount of skin and epithelial tissue to the sun. I saw no bird change from one eye to the other while staring at the sun.

This performance was carried on socially, that is, when one bird began to sun-bathe, others followed suit. Sun-bathing usually was terminated by preening and scratching.

Roosting.—Competition for roosting sites was severe. The crossbills preferred to roost in thick foliage of pine and cedar branches, but they so rapidly bit off twigs and needles that cover of this type usually was not available. I was unable to replenish this cover at the frequent intervals required by the birds' defoliating activities. Consequently, the roosting boxes already described were used. An original, uncompartmented box with, to my eyes, sufficient perch space soon was judged inadequate because of the intense fighting, which usually started as much as an hour before actual roosting. I added roosting boxes which, finally, contained a total of 20 compartments. Even this did not appreciably reduce the fighting. Perhaps strife over roosting sites is a normal part of pre-roosting behavior; it seemed to be in this captive flock.

When the crossbills roosted in the pine, they settled in thick clumps of needles at the ends of branches. Here they looked remarkably like pine cones and it is easy to visualize the protection afforded by this habit. No more than one or two birds roosted on the same twig.

Activity preceding roosting consisted of rapid flying about the cage with rapid, "excited" calling. This flying may have been an expression of the flight to roost trees in the wild. Dominant birds repeatedly chased others out of roosting compartments. The last birds to settle down each night were invariably the females lowest in the peck-order.

After the birds finally settle in their roosts and before they go to sleep, they extend and retract their long tongues in a deliberate manner. The flickering of the pale pink tongues in and out of the mouths of the birds at the rate of three to five times a second is very striking. This performance is continued for perhaps three to five seconds, followed by a pause of several seconds, and then is repeated. Individual birds continued the flickering of the tongue for at least several minutes. It is extended on both sides of the upper mandible, although not strictly alternately, and when it is fully extended it reaches well beyond the end of the bill. After a minute, more or less, of this performance, a sizable cluster of white, frothy bubbles collects on the outside of the bill where the tips cross. These bubbles seem to be saliva. After cessation of protrusion and retraction of the tongue, the bubbles soon break, leaving the bill wet and shiny.

Coincident with the manipulations of the tongue, although at a slower rate, the crossbills open and close their bills in a manner suggesting that they are stropping the edges together. An amazing feature of this "stropping" was that the birds actually crossed their bills in the "wrong" direction! Knowing of some early literature in which it was suggested that crossbills were unable even to oppose the tips of the peculiarly formed bill, it was astonishing to me to find that they could not merely oppose the tips but actually could cross their bills in either direction. When the bill was closed on the wrong side, as was frequently the case for several seconds, the mouth did not close evenly, causing the birds to look most peculiar.

The movements of the tongue and bill possibly clean the bill, although crossbills habitually wipe their bills in the same fashion as other passerines after feeding. A second possibility is that the appearance of stropping may not be accidental, that is to say, the activities may be performed specifically to reduce certain parts of the bill by abrasion. I think that the latter is the correct interpretation of the performance. In other birds, overgrowth of the tomia is prohibited by the occluding surfaces, but in crossbills the tomium of the upper mandible does not occlude on the side opposite the tip of the lower mandible nor does the tomium of the lower mandible occlude on the side opposite the tip of the upper mandible. These edges are most effectively rubbed together in the re-

versed crossing of the bill. Examination of study specimens readily reveals the effect of the stropping. The two surfaces just described are so obviously worn down in crossbills that the reverse crossing of the bill might well have been predicted from the examination of study skins alone. The moisture from the tongue seemingly lubricates the bill to make the stropping more effective, much as oil or water lubricates a whetstone.

The twisting and prying at objects and the stropping of the bill not only counteract the tendency for overgrowth which is inherent in the non-occluding bill, but have permitted crossbills to develop the bizarre bill and, thereby, to exploit a new food source. It would be interesting, indeed, to know when these traits appear in the ontogeny of crossbills; possibly they appear at the age at which the tips of the bill start to cross. Judging by the shape of the bill, the White-winged Crossbill (*Loxia leucoptera*) prevents overgrowth of the bill in the same manner as the Red Crossbill.

Loxia is a recognizable genus primarily because of the unique bill. In other respects, crossbills might well be included in *Carpodacus* or *Spinus*. In crossbills the prying and stropping are correlated behavioristic traits that seem to have made possible the existence of a morphological generic character, namely the crossed bill.

SOCIAL ORGANIZATION

Establishment of peck-order.—A fairly rigid peck-order was already established at the time of capture of the birds. Certain changes in peck-order occurred, for reasons discussed later, after the birds were in captivity, and these changes make it possible to visualize the establishment of peck-order in newly formed wild flocks and the integration of newcomers into established wild flocks.

Peck-order was of the rigid, essentially straight-line type but with some triangles of dominance. There were three social hierarchies: a peck-order in the males, a peck-order in the females, and general dominance of all males over all females (but see exceptions to latter).

Peck-order probably was established by fighting and threat displays and was maintained primarily by threat displays. Fighting in Red Crossbills involves mainly attempts to bite; in severe fights, the combatants may fly into the air, facing each other in a nearly vertical position, and attempt to bite and perhaps strike each other with feet and wings. Crossbills pulled clumps of feathers from their opponents on several occasions. Three times I observed perched, dominant crossbills seize subordinates by the primaries and hold the birds suspended in the air for a few seconds.

Most of the aggressive activity, however, took the form of threat displays, the main elements of which involved an advance with head lowered, neck outstretched, and bill widely opened in such a manner that the tip of the lower mandible was well below the tip of the upper (fig. 1). In some cases, a high-pitched, buzzy note accompanied this display. The buzzy notes characterized more aggressive displays and were always used in fighting. Less vigorous threat displays always included opening of the bill toward the subservient bird and sometimes included lowering of the head and stretching of the neck. The widely opened bill provides an effective-appearing threat; the two curved and pointed parts of the bill look to be capable of inflicting a severe bite. Actual biting followed threatening only occasionally. Threat display, alone or with the buzzy warning note, usually caused the inferior bird to retreat. When an inferior approached a dominant bird in possession of a disputed roosting site, the dominant bird would gradually open its bill as the other bird approached; actual aggressive display depended on the closeness of approach. No fixed distance of tolerance was noted; if the birds were agitated, they seemed to seek encounters with birds lower in the peck-order, often chasing them

vigorously around the cage. When the crossbills were loafing, preening, or sun-bathing, approaches as close as four inches were frequently tolerated or reacted to only mildly. Many encounters involved no obvious threatening at all; subordinate birds simply avoided dominant birds or moved away as the latter approached them.

It was clear that the head, face, and bill are the parts of the bird possessing the highest valence in recognition of individual crossbills by one another. All displays involved



Fig. 1. Threat display in a male Red Crossbill; sketched from life by Robert M. Mengel.

face-to-face postures. It may be significant that the prenuptial molt, because of its variable extent and replacement of red feathers with green feathers in the males, increased the ease of recognition of individuals, at least to human eyes. This increased ease of recognition may be of value in maintenance of the mating bond.

The importance of features of the head and, to some extent those of the neck, in individual recognition in domestic chickens has recently been shown experimentally by Guhl and Ortman (1953).

Peck-order in males.—The five male crossbills included four first-winter birds and one adult (B), judging by the color of the edgings of the tail feathers (Tordoff, 1952: 201). All had essentially red body plumage although two (O and G) had some "orangish" feathers. When observations were begun on December 31, the males had an established peck-order as shown in table 1. This hierarchy contained one triangle of dominance—male G, second from the bottom of the peck-order, dominated W, otherwise at the top

Table 1									
Peck-order in Male Red Crossbills, Based on 404 Encounters									
Male	December 31–January 12					January 14–March 25			
	Dominates					Dominates			
W	—	B	A	O	—	B	A	G	O
B		—	A	G	O	—	A	G	O
A			—	G	O		—	G	O
G	W			—	O			—	O
O				—	—				—

of the peck-order. On January 13, G suffered a head injury as a result of being frightened into flight at night by domestic cats. On January 14, G was poorly coordinated, flew erratically, and seemed to lack good depth perception. W seized this opportunity to dominate G and maintained its newly won dominance even after G recovered. I saw no effort by G to dispute W's dominance after January 14. It is noteworthy that O, the lowest bird in the peck-order, did not climb in the rankings at G's expense. Even on Jan-

uary 14, when G seemed severely handicapped, we recorded G as dominant over O in one encounter. The effect of the loss of dominance by G over W was to resolve the peck-order into a straight-line system of dominance.

Aggressiveness of males.—Table 2 illustrates the aggressiveness of the individual males. The degree of aggressiveness of males with other males is directly correlated with position in the peck-order. The despot, male W, was especially active in dominating

Table 2
Aggressiveness in Male Red Crossbills Based on 404 Male-to-Male and
620 Male-to-Female Encounters

Male	Per cent of all δ -to- δ encounters in which δ indi- cated participated as dominant bird	Per cent of all δ -to- δ encounters in which δ indi- cated dominated next lowest δ	Per cent of all δ -to- δ encounters in which δ indi- cated dominated lowest δ (O)	Per cent of all δ -to- δ encounters with δ dominant in which δ indi- cated participated	Per cent of all δ -to- δ and all δ -to- δ encounters with δ dominant in which δ indicated participated as dominant bird
W	51	23	11	26	36
B	28	6	11	19	22
A	10	3	7	10	10
G	11	9	9	16	14
O	0	—	—	29	18
Totals	100	41	38	100	100

second-ranking B, but the other males did not pay particular attention to dominating their immediate subordinates; only 41 per cent of all male to male encounters involved birds adjacent to each other in the peck-order. On the other hand, the four top ranking males were approximately equal in their aggressiveness toward the lowest male (O). This male was one party to 38 per cent of all recorded encounters between males.

The domination of female crossbills by males in non-breeding flocks provides an outlet for aggressive drives in the males ranked low in the male peck-order. Table 2 shows that male O, at the bottom of the male peck-order, was the most aggressive male in dominating the females, participating in 29 per cent of all male to female encounters. Second was male W, with participation in 26 per cent of such encounters. When all encounters in which any male participated as the dominant bird are summarized, it turns out that A is the least aggressive male. He ranked third in the peck-order of males; next in order of increasing aggressiveness was fourth-ranking G, followed by O, B, and W in that order.

Peck-order in females.—At the beginning of observations, the seven females were arranged in a hierarchy, as shown in table 3. This peck-order included two triangles of dominance and one bird (RA) figured in both. Female RA ranked fifth at this time, although in table 3 RA is listed fourth, which was her ranking at the close of observations. But RA dominated first-ranking OA and was in turn dominated by sixth-ranking RR. In the night of January 2-3, the then fourth-ranking female TR received a severe head injury through disturbance by domestic cats. On January 3, TR was unable to fly or even to feed properly and was persecuted by all females and males. I removed TR to prevent the other birds from killing her. On January 1, TR was placed back in the cage although she was still very poorly coordinated. Again she was vigorously attacked by the other birds and was removed once more. On January 6, TR was once more placed in the cage where she seemed capable of feeding and avoiding most of the other birds. Female RA, however, repeatedly sought out TR and attacked her. In this period, RA attained dominance over TR and ascended to fourth place in the peck-order where she

remained throughout the remainder of the period of observations. By January 7, TR was again exercising her dominance over females RR and OR.

One consequence of TR's efforts to regain her position in the peck-order after her injury was an increase in her aggressiveness. Through her increased aggressiveness she attained dominance over male G. This dominance was maintained uneasily until March 7; G frequently fought back unsuccessfully. On this date G began to contest TR by violent fighting. This fighting continued intermittently until March 15, when, after a particularly violent fight, TR seemed to have been reinjured and died in a few hours. I do not know whether G inflicted the injury or whether TR flew against some object while fighting. Her death was caused by hemorrhage in the brain.

Table 3
Peck-order in Female Red Crossbills, Based on 1,120 Encounters

Female	December 31-January 2							January 3-March 31						
	Dominates							Dominates						
OA	—	GR	WR	TR	RR	OR	—	GR	WR	TR	RR	OR	—	
GR	—	—	WR	RA	TR	RR	OR	—	WR	RA	TR	RR	OR	
WR			—	RA	TR	RR	OR	—	—	RA	TR	RR	OR	
RA	OA			—			OR	OA		—	TR		OR	
TR ¹				RA	—	RR	OR				—	RR	OR	
RR				RA		—	OR			RA		—	OR	
OR							—						—	

¹ TR died March 15.

All changes in peck-order thus far described have been attributable to injuries that impaired the ability of the injured bird to coordinate properly. In fact, the clearly abnormal behavior—convulsions, coma, and the like—of TR after her injury stimulated vigorous aggression by all other birds. In contrast to this was the behavior of female GR, which injured one hallux so badly that I was forced to amputate it. The injury and subsequent amputation were a heavy drain on the vitality of GR. For about two weeks, GR avoided the other crossbills and spent most of the time perched in a corner of the cage. In spite of her obvious disablement, no crossbills challenged her high position (number two) in the peck-order. When approached too closely, GR responded with a threat display in normal fashion. Seemingly, an injury must impair the ability of the crossbill to react normally in individual encounters if the injured bird's position in the peck-order is to be affected. Another case in point is that of male A, the bird originally captured with a broken wing. I saw no evidence that A was handicapped in any encounters because of its injury, which ultimately healed sufficiently to permit fairly good flight.

Aggressiveness of females.—Comparative aggressiveness of the female crossbills is presented in table 4. The frequency of dominant participation in encounters is directly correlated with rank in the peck-order, as was true also for the males. One exception is provided by female GR, however, which ranked second in the peck-order but fourth in aggressiveness. The females also agreed with the males in that aggressive behavior did not seem directed disproportionately to either the lowest ranking female (OR) or to females immediately subordinate to the aggressor. (It should be noted that the percentage figures in tables 2 and 4 are not directly comparable. Other things being equal, percentages for the females would be smaller than for the males because the flock contained seven females and only five males.)

The total number of female-to-female encounters was 1,120. The total number of

male-to-male encounters (with two fewer male birds than females) was only 404. If the 620 male-over-female encounters are added to the latter figure and the few female-over-male encounters are added to the former, aggressiveness in the two sexes is approximately equal.

Factors affecting social dominance.—Shoemaker (1939:404) found that male canaries regularly dominate females except during the breeding season, when dominance is reversed for the mated pair. In my crossbills, no actual mating took place in the period of observation. Female RR, however, was frequently noted in courtship feeding with males W and B and she dominated both males. It is interesting to note that RR ranked

Table 4
Aggressiveness in Female Red Crossbills, Based on 1,120 Female-to-Female Encounters

Female	Per cent of all ♀-to-♀ encounters in which ♀ indicated participated as dominant bird	Per cent of all ♀-to-♀ encounters in which ♀ indicated dominated next lowest ♀	Per cent of all ♀-to-♀ encounters in which ♀ indicated dominated lowest ♀ (OR)	Per cent of all ♀-to-♀ encounters in which ♀ indicated dominated most frequent opponent
OA	30	3	5	OA > RR 9
GR	13	4	1	GR > TR 4
WR	20	5	6	WR > RR 7
RA	21	11	2	RA > TR 11
TR	9	4	4	TR > RR 4
RR	7	2	2	RR > RA 5
OR	—	—	—	—
Totals	100	29	20	40

sixth among females while W and B were first and second, respectively, among the males. The total number of recorded encounters involving female RR and males W and B was 39; of these, RR dominated 36. It seems to me that RR may have achieved dominance over W and B through participation in the early stages of pair formation. Further observations should show the effect of mating on male-female dominance in Red Crossbills.

Age may be unimportant in determining position in the peck-order. Only male crossbills can be aged by plumage characters. The single adult of the five males ranked second. Shoemaker (1939:399) found that age made little, if any, difference in dominance in canaries.

Size, at least within one subspecies, seems also to play no part in determining dominance in crossbills. Female RR ranked sixth, yet was the largest of the females. Shoemaker (1939:399-400) determined that weight did not affect dominance in canaries.

Effect of captivity on peck-order.—A measure of the rigidity of the peck-order in my flock of crossbills is the fact that only 29 encounters of the total of 2,144 were recorded that involved reversals of the dominance situations shown in tables 1 and 3. No reversals were recorded between any two males. Of the 29 recorded for females, 14 were encounters in which TR dominated WR (WR dominated TR 17 times). Some of the others may have been the result of faulty observation or recording.

In wild flocks of crossbills peck-order is probably established and maintained as described here. Captivity may have caused the peck-order to be somewhat more rigid, however, by increasing the number of individual contacts. I recorded 2,144 encounters in 26 hours of observation—an average of 82 encounters per hour or 14 contacts per bird per hour, since each encounter involves two birds. In wild flocks, encounters are probably not nearly so frequent as in my captive flock. I have frequently seen threat displays and dominance, however, in feeding flocks of wild crossbills.

SURVIVAL VALUE OF SOCIAL ORGANIZATION

Some obvious benefits of social organization in birds have been noted by other authors. Guhl (1945:340) found that food consumption and egg production in domestic hens were higher in organized flocks than in flocks kept disorganized by introduction of new birds. Shoemaker (1939:381) remarked that social groupings may have survival value in several ways: "(1) greater defensive strength in numbers; (2) more eyes in more directions to detect predators; (3) heat conservation in severe weather; (4) ease of finding food to be shared by the group; (5) proximity of sexes insuring greater fertility; and finally, (6) group breeding may result in lessened mortality of the young."

Red Crossbills and other carduelines would seem to derive special benefits from their social habits in finding food. Characteristically, crossbills feed on seeds of conifers, especially pines. Many kinds of pines do not fruit each year and food for crossbills, therefore, often occurs abundantly but in small patches scattered over extensive areas. The gregarious nature of crossbills leads them to call to passing flocks, even while feeding. The passing flocks then often join the feeding birds and share in the food. The strong powers of flight of carduelines enable them to cover long distances in search of food.

The existence of a well defined peck-order would seem advantageous in simple economy of effort. The peck-order permits resolving of disputes with a minimum of effort. Considering the gregarious nature of crossbills, it seems that the peck-order prevents much fighting and consequent waste of energy.

I observed that social dominance was exercised in all situations. The clear benefits to the individual crossbill of high rank in the peck-order, however, were most evident in regard to food and roosting sites. When favored food such as piñon nuts was placed in the cage, the crossbills fed approximately in order of their rank in the peck-order. That is, the highest males fed first and the lowest females fed last.

In regard to roosting, I could not see that any sites offered special advantages over other sites. Even so, strife was severe and dominance was repeatedly exercised by the high ranking birds. Evening after evening female OR, the only bird in the flock that had no subordinate, was the last to find a place to roost. In general behavior, OR was a timid, poorly adjusted bird and this probably resulted from, or caused, her low rank in the peck-order.

The triangles of dominance deserve comment. The triangles seemed to result in decreased efficiency of the flock. As an example, when females OA, RA, and RR were searching for roosting sites, I noted that their dominance relationship (OA dominated RR, RR dominated RA, RA dominated OA) tended to keep all the females agitated. First, one of the three females would pick a roost, then in turn each of the three birds would evict its subordinate in the triangle and also other subordinate females. The triangles clearly promoted confusion and when female RA was removed, experimentally, strife over roosting sites was noticeably diminished. It is probably significant that the

changes observed in the peck-order in this flock were changes that tended to eliminate triangles and to promote a straight line system of dominance. In view of this, it is surprising that canaries (Shoemaker, 1939) do not establish a straight line peck-order but instead show "peck-right dominance," in which pecks are dealt by both members of most encounters, the bird which pecks the most being judged to be dominant.

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SUMMARY

A flock of 12 Red Crossbills trapped in eastern Kansas was caged and studied, with the following results:

Individual crossbills in feeding on pine cones were found to be either "right- or left-handed," depending on the direction of crossing of the bill. Prying and "bill-strooping" seem to prevent overgrowth in the non-occluded bill.

Bathing and sun-bathing were usually performed socially.

Peck-order was established and maintained by fights and threat displays; peck-order was essentially the straight line type but with some triangles of dominance. Three hierarchies were present in the flock: (1) a peck-order of males; (2) a peck-order of females; and (3) dominance of males over females.

Some changes in the peck-order were directly attributable to injuries. Injuries affecting ability to coordinate and behave "normally" are more likely to affect rank in the peck-order than injuries such as a broken wing or damaged foot.

The top-ranking male was the most aggressive male and was especially active in dominating the second-ranking male. Other males seemed not to pay particular attention to their subordinates. The lowest male was dominated about equally by all four males above him and was a party to 38 per cent of all male-to-male encounters. The lowest-ranking male was most active in dominating females, followed closely by the top-ranking male.

Aggressiveness in females, as in males, was directly correlated with rank in peck-order and did not seem directed disproportionately to either the lowest ranking female or to the aggressor's immediate subordinate. Males and females were about equally aggressive.

Captivity was judged to have increased the rigidity of the social hierarchy through increasing frequency of individual contacts but it was thought not to have altered basic behavior patterns.

Social organization results in more efficient functioning of the flock as a unit and has definite survival value.

Triangles of dominance imposed on a basically straight-line peck-order are disruptive and disadvantageous, at least in small flocks. Observed changes in the peck-order tended to eliminate triangles of dominance.

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NESTING AND FEEDING OF THE BLACK OYSTER-CATCHER NEAR MONTEREY, CALIFORNIA

By KEN LEGG

About fifteen pairs of Black Oyster-catchers (*Haematopus bachmani*) are resident at Point Lobos Reserve a few miles south of Monterey, California. For the most part they nest on offshore inaccessible islands. However, in the years 1951 and 1953, a pair nested on an accessible part of the mainland. Webster (Wilson Bull., 53, 1941:141-156 and Condor, 43, 1941:175-180) has already reported a study of the breeding habits and feeding of the Black Oyster-catcher in Alaska. My findings, while similar in most respects, serve to substantiate Webster's report as well as to provide new information from a more southern point in the oyster-catcher's breeding range.

On June 10, 1951, a nest was found on a high conglomerate flat devoid of practically all vegetation. The nest, placed on a point projecting seaward, contained two eggs and was composed of about a quart of small angular pebbles carried to the site. The nest was several hundred yards from any well used trail, but a person walking along the nearest trail appeared to the incubating birds below as a silhouette against the skyline. Each time a human appeared on the trail, the incubating bird would steal quietly from the nest. On Sundays, when visitor traffic was greatest, the birds were absent from the eggs for prolonged periods, probably for the entire afternoon. During this particular year, fog and cold winds were unusually prevalent, with the sun shining hardly at all. The eggs probably became chilled during one of the extended periods when incubation was not in progress, for they did not hatch. The incubation period of the Black Oyster-catcher is from twenty-seven to thirty days. It is interesting to note that this pair incubated until August 4, a total of 55 days, or just double the normal period. On this date the nest was deserted and the eggs later disappeared.

There was no nest on the point in 1952, but on May 24, 1953, a nest with one egg was found. It was six feet from the nest of 1951, and it was likewise composed of small angular pebbles. It was beside a six-inch clump of spurrey, the only plant on the table-like rock. On May 25, there was still one egg. On May 26, there were two eggs and at 5:30 p.m. one of the birds was incubating. Human interference was similar to that of 1951, but the weather was dryer, sunnier and warmer, and although the eggs were left uncovered as long as in 1951, the warmer days apparently kept them from chilling.

On June 21, at 8:00 p.m., approximately twenty-six days after incubation began, one egg was cracked. Peeping and scratching could be heard from within the shell. At 11:30 a.m. on the following day there was no visible development beyond that of the previous day, but one young was calling loudly from inside the shell in a voice which already resembled somewhat the parents'.

On June 22, at 8:00 p.m., neither young was out of the egg but both were now calling loudly. At 7:30 a.m. on June 23, the twenty-ninth day, one egg had a small hole. At 7:00 p.m. on this same date, both young were out of the egg and one was dry.

Since the littoral marine fauna of Point Lobos is markedly different from that of the Alaskan coast studied by Webster, it seems advisable to report food items in the diet of the young oyster-catchers. Webster (Condor, 43, 1941:175) states that "the best method of determining the food of the Black Oyster-catcher . . . is to collect the shells scattered around young birds which are being fed by the parents." My nest of 1953 was exceptionally suitable for a study of this type because it was on a pedestal-like column separated from any other flat area by a small chasm a foot across, and although

I could easily cross this, the young oyster-catchers were confined to a round area about eighteen feet in diameter.

Prior to hatching of the eggs all weathered shells, fish bones and other loose objects were cleared from the nest site. Until July 8, at age fifteen days, the parent birds were observed bringing food to both young. On this date one young disappeared. On July 17, at an age of 24 days, the second young disappeared. During this time at least 457 shelled invertebrate animals were carried to the young. Although most of the shells were recovered, some were seen to go flying off into space and into the water as the parent, holding the meat in its bill, flicked the shell off. A few which became lodged on the vertical side of the rocks are included in the count.

Table 1

Size Distribution of Limpets Taken by Black Oyster-catchers

Range in centimeters	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	Totals
<i>Lottia gigantea</i>	1	19	165	106	24	6	0	1	322
<i>Acmaea digitalis</i>		8	4						12
<i>Acmaea scutum</i>			3	2					5
<i>Acmaea scabra</i>		4							4
<i>Acmaea limatula</i>				1					1
<i>Acmaea pelta</i>		8	49	10					67
	1	39	221	119	24	6	0	1	411

The chief food brought to the young was limpets, particularly the owl limpet (*Lottia gigantea*) which is common on exposed, wave-swept rocky coasts where oyster-catchers occur. Species of limpets preyed upon and their size ranges are summarized in table 1. This lot also included one small shell of *Haliotis rufescens* and 11 uneaten limpets that fell from other shells (7 *A. scabra* and 4 *A. pelta*). These specimens were identified by Drs. Frank A. Pitelka, Harry K. Fritchman, and Allyn G. Smith.

Thirty-four food items were identified earlier from the same nest by Mr. Merton Hinshaw of the Pacific Grove Museum of Natural History, as follows:

<i>Thais emarginata</i> , 4	<i>Acmaea scabra</i> , 5	<i>Nuttalina californica</i> , 1
<i>Lottia gigantea</i> , 3	<i>Diadora aspera</i> , 1	<i>Acmaea scutum</i> , 10
<i>Acmaea mitra</i> , 1	<i>Haliotis cracherodii</i> , 2	One small mussel shell
<i>Acmaea</i> sp. (small), 3	<i>Acmaea digitalis</i> , 3	Several fragments of crab carapace

Although the California mussel (*Mytilus californianus*) is an important food item of adult oyster-catchers, observations show that almost none was brought to the young.

Natural Bridges State Park, Santa Cruz, California, July 6, 1954.

FROM FIELD AND STUDY

Toxostoma ocellatum and Diglossa baritula in Hidalgo.—At the invitation of Sr. and Sra. Carlos Sánchez Mejorada, Jr., Mrs. Newman and I had the pleasure of spending the night of June 4 and the morning of June 5, 1949, at the Hacienda Velasco, in the village of Omitlán, in southern Hidalgo, México. Since Omitlán is only four miles in an airline northeast of Real del Monte, a famous type locality and the scene of much intensive bird collecting over the years, it seemed unlikely that we should encounter much of novelty in so short a time. To our surprise, however, we succeeded in taking, in the near vicinity and within the space of four hours, two species for which there is no previous published record in the state.

Omitlán is a dusty little village situated at an elevation of 7400 feet in an arid gap between high mountains. But behind the high walls of the Hacienda, the growth is green and luxuriant. Beneath towering eucalyptus trees, swarming with hummingbirds, flower-bordered walks thread their way through well-tended gardens, past walls overgrown with climbing vines. On such a wall, within twenty feet of the house, I discovered a small slate-gray and russet bird flitting in the English ivy like a warbler. Upon collection, it proved to be an adult male Mexican Diglossa (*Diglossa baritula baritula*). Later on the same morning, I shot a second specimen from a small tree on the grounds, also a male but not in fully adult plumage.

Although the state of Hidalgo is not included in the range of the species as stated in current works, the Diglossa is of more than casual occurrence in the small area of immured greenery furnished by the Hacienda. Sr. Sánchez, who is a keen observer of birds and a longtime student of the fauna of the region, informed me that he has seen it in the garden on at least five previous occasions. Comparison of our two specimens with material in the United States National Museum has shown that the Omitlán birds are assignable to the nominate race.

On a trip with Sr. Sánchez that same day to the top of El Zumate, a 10,000-foot peak on the outskirts of the village, we secured a male Ocellated Thrasher (*Toxostoma ocellatum*). In contrast to the valley below, the slopes of the mountain are heavily wooded; and at the 9000-foot level there are small bushy clearings bordered by forests of conifers. The thrasher was shot at the edge of one of these open places, about forty feet above the ground in the branches of a fir. A second individual, possibly its mate, escaped. The large, heavily-spotted Ocellated Thrasher is a rather uncommon bird in collections, previously taken only in the states of México, Puebla, and Oaxaca.

All three specimens mentioned are now in the Museum of Zoology at Louisiana State University. I am indebted to Sr. and Sra. Sánchez for the hospitality shown us and to Dr. Alexander Wetmore and Dr. Herbert Friedmann of the United States National Museum for access to the comparative material in collections under their care.—ROBERT J. NEWMAN, *Museum of Zoology, Louisiana State University, Baton Rouge, Louisiana, April 27, 1954.*

Willet Nesting in the Central Sierra Nevada, California.—There are no records, as far as I know, of the Willet, *Catoptrophorus semipalmatus*, nesting in California south of Plumas County. Grinnell and Miller (Pac. Coast Avif. No. 27, 1944:145) say: "Strangely, there appear to be few records of this wader, even as a transient, for points in California east of Sierran divides and south of Plumas County." Consequently it is worth reporting that on May 31, 1954, Celeste Kirsher discovered a brooding bird at the south end of Lake Tahoe, Eldorado County. The nest was in the open on a sand spit south of Pope Beach. So reluctant was the bird to leave the nest that it permitted itself to be gently rolled to one side while the two eggs were examined, and it allowed its wing to be slightly extended to reveal the distinguishing black and white pattern. Both adults were seen in the area on June 27. On July 3, however, the nest was found deserted. Only one egg contained an embryo. The eggs were brought to the Museum of Vertebrate Zoology and compared with Willet eggs in its collection.

It should be added that during the past two years, 1952 and 1953, Willets have been observed in this area during the breeding season.—WILLIAM K. KIRSHER, *Sacramento, California, July 6, 1954.*

Another Record of the Painted Redstart in Southern California.—The Painted Redstart (*Setophaga picta*) has been recorded previously from southern California four times (see Thornburgh, Condor, 55, 1953:318). Moreover, all have been winter records. The earliest fall record was Septem-

ber 26, 1943, and the latest spring record was March 21, 1944. On December 28, 1953, a Painted Redstart was observed in Mill Creek Canyon, San Bernardino Mountains, by a group taking the Audubon Christmas Bird Count. This bird had been seen about a week before at the same spot by some of the same observers. A Painted Redstart was also present at the same spot in the winter of 1952, as it was seen by two observers on December 14, 1952, and reported to me the same day.

The 1953 record comes from an elevation of about 3600 feet, at the junction of Mill Creek with Mountain Home Creek. The dominant vegetation is alder (*Alnus rhombifolia*) and western sycamore (*Platanus racemosa*) with a thick understory of various vines and shrubs, principally blackberry (*Rubus vitifolius*) and California bay (*Umbellularia californica*). The redstart foraged in the shrubbery and on alder trunks where it drank sap from a series of excavations made by Sapsuckers (*Sphyrapicus varius*). The bird appeared at about the same time that wintering Audubon Warblers and other summer residents of the surrounding higher mountains appeared at the lower elevations. —JOHN D. GOODMAN, *Biology Department, University of Redlands, Redlands, California, March 24, 1954.*

Additional and New Bird Records for Utah.—During the past few years, specimens of birds not mentioned in the two check-lists of the birds of Utah (Behle, Condor, 46, 1944:67-87; and Woodbury, Cottam and Sugden, Bull. Univ. Utah, 39, 1949:1-40) and also additional specimens of birds relatively uncommon in Utah have been collected in the northern part of the state. Data extending the ranges of two species are also given here. Acknowledgments are made to William H. Behle, University of Utah, and Howard Knight, Weber College, for the use of data from specimens in their respective institutions. I am grateful to Herbert Friedmann and Gorman M. Bond of the United States National Museum for the identification of some of the specimens listed here. Thanks are given to Angus M. Woodbury for the use of Woodbury, Cottam and Sugden's unpublished manuscript on the birds of Utah and to William G. Denzer, Harold J. Egoscue and M. Raymond Lee for the collection of specimens listed below. Specimens for which no collector is mentioned were taken by the writer. Specimens not otherwise designated are located in the University of Utah Museum of Zoology. Other specimens mentioned are at Weber College (WC) and Utah State Agricultural College (USAC).

Lophortyx gambelii gambelii. Gambel Quail. On May 13, 1952, an adult female Gambel Quail was collected from a small covey along the Green River at about 4100 feet, near the town of Green River, Emery County. The presence of a full sized egg in the oviduct of this specimen suggests that it was probably nesting. Woodbury *et al.* (*op. cit.*:11) list Wayne County as the northern extremity of the range of the Gambel Quail in eastern Utah. The present data indicate that this species is a resident at least as far north as Green River, Emery County (40 to 60 miles north of Wayne County). It is possible that this species has followed northward along Green River where the most suitable habitat appears to be adjacent to rivers and streams.

Otus flammeolus flammeolus. Flammulated Owl. One more specimen added to the several known from the state is a male found freshly killed on the highway near the mouth of Ogden Canyon, 4425 feet, Weber County, on May 26, 1950, by M. Raymond Lee (WC).

Colaptes auratus luteus. Yellow-shafted Flicker. In his check-list for Utah, Behle (*op. cit.*:76) added this woodpecker to the state-list on the basis of a sight record (Grater, Condor, 45, 1943:76) and stated that it may have been a hybrid with *Colaptes cafer*. Woodbury *et al.* (*op. cit.*:19) do not list this flicker, but do list a "Hybrid Flicker *Colaptes cafer* x *auratus*." Behle and Selander (Wilson Bull., 64, 1952:28) recorded an adult male specimen from Salt Lake County, which they stated was closer to *C. a. luteus* on the basis of a scarlet nuchal band and a predominantly yellow lining of the wings and tail, the color of which was actually intermediate between the two species. Other characteristics, such as the gray color of the throat and neck and the red malar stripes were typical of *C. c. collaris*. An adult female flicker captured October 14, 1953, in a wooden building at the south end of the Cedar Mountains, Tooele County, shows even greater affinities to *C. auratus*. This specimen has a brown throat and neck which shows a slight grayish cast, probably an influence of *C. c. collaris*, and a gray crown with a fully developed nuchal band. The feathers on the breast are more tan in color showing less influence of red. The lining of the wings and tail are predominantly yellow, yet the shafts of the feathers are orange, indicating intergradation with *C. c. collaris*. A male specimen of *C. a. luteus* mounted in a life-like pose by Wayne L. Burton, an amateur taxidermist, was collected at Syracuse, Davis County, early in December, 1946 (WC). This specimen shows no indica-

tion of hybridization. It has a scarlet nuchal band, black malar stripes, brown throat and neck, gray crown and yellow linings of tail and wings.

Anthus spinoletta. Water Pipit. Woodbury *et al.* (*op. cit.*:26) record the western race, *pacificus*, in Utah on the basis of a single specimen collected by Twomey (Condor, 46, 1944:89) near St. George, Washington County. Eleven specimens of this race were collected from April 14 to April 30, 1953, and from September 24 to December 16, 1953, at Government Creek, 4328 feet, 4 miles north of Camel Back Mountain, and at Orr's Ranch, 4600 feet, Skull Valley, both in Tooele County. These birds show that *A. s. pacificus* is probably more common than the one record in the literature indicates. Of these eleven birds, one shows affinities toward *A. s. geophilus* and three toward *A. s. alticola*. These birds were identified by G. M. Bond. Five specimens collected on April 30, 1953, at Government Creek, and one on October 8, 1952, at Bennion Ranch, 4800 feet, Indian Creek Canyon, west side Simpson Mountain in Tooele County, were identified as *A. s. geophilus* by G. M. Bond. This race has not been recorded previously from the state. With but one exception, each subspecies appeared to maintain distinct flocks.

Vireo olivaceus. Red-eyed Vireo. Although Twomey (Ann. Carnegie Mus., 28, 1942:437) reported this vireo as present in spring and fall migrations in the Uintah Basin and also observed them in large numbers along the Provo River, he secured only one specimen. Woodbury *et al.* in their unpublished manuscript of the birds of Utah record only two other specimens from Utah. A specimen was collected by Allen (Bull. Mus. Comp. Zool., 3, 1872:167) on September 8, 1871 (in Mus. Comp. Zool.) near Ogden, where he considered them to be more or less common from September 1 to October 8, 1871 (Woodbury *et al.*, unpublished manuscript). Another specimen was collected east of Logan in Cache County, May 30, 1941 (USAC). A fourth specimen was recently obtained on September 11, 1953, at the Deseret Livestock Company Ranch, Iosepa, 4500 feet, Skull Valley, Tooele County. This bird was apparently a lone migrant.

Vireo solitarius cassinii. Solitary Vireo. Woodbury *et al.* (Bull. Univ. Utah, 39, 1949:27) list the latest known date in fall migration of this species as September 27. A specimen of this uncommon migrant was collected on October 10, 1953, in an extensive but thin stand of tall willows near Clover Creek in the community of Clover, 5100 feet, east side of Stansbury Mountains in Tooele County.

Setophaga ruticilla tricolora. American Redstart. Since there is no reference in the literature to the occurrence of the redstart in the west desert areas of Utah, it is deemed advisable to record the collection of three specimens from this region. Two specimens were collected from five immature or female redstarts observed at Warburton's ranch (formerly McKellar's Ranch) on August 31 and September 1, 1953, at about 4600 feet on the east base of Pilot Mountain, Box Elder County. One bird of indeterminable sex or age was collected from a clump of willows near a spring on August 31, while a second specimen, an immature female, was collected from the same willow clump on September 1. Warburton's Ranch contains a number of small springs and water courses bordered by willows.

On September 22, 1953, a female redstart was collected from a juniper tree at Oochrona Springs, 4600 feet, west side of Cedar Mountains, Tooele County. The dominant vegetation near the spring is juniper (*Juniperus utahensis*), squawbush (*Rhus trilobata*), tamarix (*Tamarix pentandra*), greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamnus* sp.). An additional redstart was observed by Harold Egoscue in the junipers at Cane Springs, 4700 feet, about 2 miles south of Oochrona Springs, on September 23, 1953. These two birds were undoubtedly migrants.

Icterus parisorum. Scott Oriole. The northernmost published record of this species in western Utah is an observation by Long in an orchard near Nephi, Juab County, on May 17, 1942 (Condor, 45, 1943:39). On May 7, 1953, a male oriole of this species was seen in some junipers by Dale Parker and myself on the southeast end of the Cedar Mountains, 4700 feet, in Tooele County; it could not be secured as a specimen.

Euphagus carolinus. Rusty Blackbird. A male of this species was collected near a drainage ditch following a snowstorm on November 24, 1952, 3 miles east of the north end of Camel Back Mountain, 4328 feet, in Tooele County. This constitutes a first record for the Rusty Blackbird in Utah. The identification of this specimen was verified by Herbert Friedmann.

Zonotrichia querula. Harris Sparrow. Woodbury *et al.* (*op. cit.*:34) list the first known fall date in Utah for this bird as October 27. On October 21, 1953, an immature male was collected in greasewood, at Government Well, 4328 feet, northeast of Camel Back Mountain, Tooele County.

Zonotrichia atricapilla. Golden-crowned Sparrow. In Utah this sparrow is known from two specimens (Long, Condor, 38, 1936:89, and Greenhalgh, Condor, 50, 1948:46) and two observations, one by Greenhalgh (*loc. cit.*) and another by Grater (Woodbury *et al.*, unpublished manuscript). A third specimen was recently collected by Harold Egoscue at Cane Springs, 4800 feet, west side of Cedar Mountains, Tooele County, on October 13, 1952.

Zonotrichia albicollis. White-throated Sparrow. Woodbury *et al.* (Bull. Univ. Utah, 39, 1949:35) list this bird as a casual winter resident of northern Utah on the basis of six observational records. An immature female collected at Orr's Ranch, Skull Valley, Tooele County, on October 12, 1953, is apparently the first specimen of the White-throated Sparrow known from Utah.

Calcarius ornatus. Chestnut-collared Longspur. An immature male longspur, which was collected near Government Creek, 4 miles north of Camel Back Mountain in Tooele County on October 14, 1953, proved to be of this species. This species has not been taken previously in the state.

Calcarius lapponicus. Lapland Longspur. Since Killpack (Condor, 55, 1953:152) acquired the first specimen (*C. l. alascensis*) of this species in eastern Utah, two additional specimens have been collected in western Utah. An adult female, which was captured during banding operations by W. G. Denzer on April 13, 1953, was put up as a study skin. It was trapped in a marshy area at the end of Government Creek, 4 miles north of Camel Back Mountain in Tooele County. This specimen was assigned to *C. l. lapponicus* by G. M. Bond and probably should be considered as an accidental visitant in Utah. On November 3, 1953, an adult male, which Bond identified as *C. l. alascensis*, was also collected near Government Creek. This specimen and the aforementioned Chestnut-collared Longspur were both collected in sparse vegetation along the creek. None of these longspurs appeared to be among the numerous flocks of Horned Larks present in the area. These birds were collected during apparent migration. Further collecting is required, however, to determine the true status of this species in Utah.—RICHARD D. PORTER, *University of Utah, Dugway, Utah, May 21, 1954.*

Nomenclature of the Black-throated Sparrows of Chihuahua and Western Texas.—In 1934 van Rossem (Bull. Mus. Comp. Zool., 77:487) described a race of the Black-throated Sparrow from Chihuahua, designating it *Amphispiza bilineata confinis*. It was based solely on specimens collected by M. Abbott Frazar at or near the type locality, Chihuahua City. Burleigh and Lowery (Occas. Papers Mus. Zool., no. 8, 1940:146) correctly pointed out that the Frazar specimens are faded, a situation subsequently well understood by van Rossem. Indeed it is now generally recognized that all of Frazar's material was prepared in some way which led to fading and that they are quite unreliable for color comparisons. I have seen samples of the original material of *confinis* in the Dickey Collection and concur with van Rossem that they are much paler than specimens of nearby races of the species, but of course they are meaningless because of the postmortem alteration. Burleigh and Lowery surmised that nonetheless *Amphispiza bilineata opuntia* of western Texas and *confinis* might be different but implied correctly that no definite statement about this matter could be made until recently collected specimens from Chihuahua were available.

Through the efforts of Robert K. Selander, whose field work in México has been supported by the Associates in Tropical Biogeography, I now have at hand a male and a female Black-throated Sparrow taken 16 miles southeast of Chihuahua City on March 11, 1954. These near topotypes are in no sense pale like the type series of *confinis*. They are in fact dark above and match fairly closely the race *grisea* of the Mexican plateau to the southward. They are not the extremely dark manifestation of that race but they are quite readily allocated to it. I have examined similar birds from Camargo in southern Chihuahua. The dark coloration of these normal Chihuahuan specimens contrasts with the lighter-backed *A. b. opuntia* of western Texas and the light warm brown *deserticola* of northwestern Chihuahua. The size differentials among the races mentioned are not in any sense complete and the somewhat short wings (♂ 64.0 mm.; ♀ 63.4) and tails (♂ 59.5; ♀ 58.2) of the recently taken pair are not considered significant, as *opuntia* and *grisea* may at times be this small. The pair was not in full breeding condition (testis 2.5 mm. long), but the birds can hardly be construed as migrants as no dark population exists to the north from which they could be derived.

We may conclude, therefore, that the diagnostic characters claimed for *confinis* are wholly attributable to the extreme postmortem fading of the Frazar specimens and that the population of the area concerned is referable to the race *grisea*, *confinis* thus becoming a synonym. *Grisea*, then, extends north from Hidalgo to central Chihuahua and at least southern Coahuila. The clarification of this

situation in Chihuahua means that the well differentiated form of west Texas can be designated neither *grisea* nor *confinis* (see Twentieth Suppl. A.O.U. Check-list, Auk, 62, 1945:448-449) and should bear the name *Amphispiza bilineata opuntia* Burleigh and Lowery (Occas. Papers Mus. Zool., no. 6, 1939: 68).—ALDEN H. MILLER, Museum of Vertebrate Zoology, Berkeley, California, September 16, 1954.

Notes on the Occurrence of Birds in Chiapas, Mexico.—Some of the following species apparently have not been recorded from Chiapas and others are supposed to be rare or else their ranges are poorly known.

Falco peregrinus. Duck Hawk. Occasionally I have seen individuals in spring, mainly near the seacoast, at Arriaga and Tonalá. I collected one adult female at Tuxtla Gutierrez on March 14, 1953.

Amaurolimnas concolor. Uniform Crane. On December 15, 1951, I found a half mummified specimen of this rare rail on the dry shore of a large brackish swamp near La Gloria, Arriaga. It is now specimen no. 357 in my collection.

Caprimulgus salvini. Tawny-collared Nightjar. I collected one female on June 18, 1949, at Rancho Santa Julia, Ocozocoautla. I am much indebted to Dr. Frank A. Pitelka and Dr. Robert A. Norris for the identification of the specimen.

Streptoprocne semicollaris. White-naped Swift. Although I have been unable to obtain specimens, large swirling flocks of this species were watched with binoculars several times during the fortnight I spent at ranch Nuevo Mundo, Pueblo Nuevo Solistahuacan, altitude 1900 meters, April 15 to 30, 1952.

Catherpes mexicanus. Canyon Wren. The species is sedentary on the cliffs and canyons around Tuxtla Gutierrez and other regions of Chiapas. The following are some of my sight records: Three individuals were seen on March 8, 1946, at Cerro Mactumatzá; four individuals were seen on April 28 and three more on June 24, 1947, at Arroyo San Roque, Tuxtla Gutierrez. Several individuals were seen during my stay at Rio de la Venta, selvas de El Mercadito, Cintalapa, from May 16 to 30, 1949. One pair was seen on November 22, 1950, at Cerro de la Sepultura, Arriaga. I collected one female on February 4, 1948, at Loma Larga, Tuxtla Gutierrez.

Melanotis hypoleucus. White-breasted Blue Mockingbird. This species is a fairly common resident in suitable localities at altitudes from 1000 to 2000 meters. I have found it very common near Ocozocoautla (ranchos Meyapac, Santa Julia, and El Resinto), Tuxtla Gutierrez (Cerro del Sumidero, La Chacona), Pueblo Nuevo Solistahuacan (Rancho Nuevo Mundo). I collected one male on September 18, 1945, at Montecristo, one female on June 2, 1954, at El Sumidero, Tuxtla Gutierrez, two males and one female on March 23, 1946, at Rancho Meyapac, and one male and two females on July 5, 1949, at Rancho Santa Julia, Ocozocoautla.

Granatellus venustus. Red-breasted Chat. Occasionally it is possible to encounter small flocks or lone individuals of this species in the hills around Tuxtla Gutierrez. From a flock of six birds I collected one male and one female on May 29, 1946, at El Zapotal. I collected another male from a flock of three on April 28, 1947, at Arroyo San Roque. Three more males and one female were collected on June 10, 1947, at Cerro Mactumatza; one male was alone and the female of the pair had a well developed brood patch. Aside from this record I have found occasional flocks or lone individuals, but because of the rarity of the species I have not collected more specimens. I have noted that the species gathers in flocks of up to eight birds, the sexes mixed, that break into pairs at the breeding season.

Icterus maculi-alatus. Bar-winged Oriole. I have collected the following specimens: One male, August 18, 1945, one female, May 12, 1951, Rancho Meyapac, Ocozocoautla; one male, April 24, one immature male and one adult male, July 15, 1949, Santa Julia, Ocozocoautla; one female, three adult males, and one immature male, May 22, 1954, Cerro Ombligo, Villa Allende; two females and three males, June 2, 1954, Cerro del Sumidero, Tuxtla Gutierrez. I found the species fairly common at Cerro Ombligo and Cerro del Sumidero, at least during May and June.

Passer domesticus. English Sparrow. Four years ago I recorded the first appearance of the species in Chiapas (Condor, 52, 1950:166). At present it has increased and is well established in Tuxtla Gutierrez, where there are about fifty birds living and nesting in the central park.

Passerina leclancherii. Orange-breasted Bunting. I watched several pairs and small flocks of three to five individuals feeding on the ground in March of 1950 and again in April of 1951 near the seacoast at La Gloria, Arriaga. I collected three here on March 23, 1950.—MIGUEL ALVAREZ DEL TORO, Instituto Zoológico del Estado, Tuxtla Gutierrez, Chiapas, México, June 25, 1954.



Male Red-shafted Flicker at nest hole in yellow pine stump.
Photograph taken by John Blackford at Libby, Montana, on June 9, 1944.

NOTES AND NEW

In conjunction with the AAAS annual meeting to be held in Berkeley, California, December 27-30, 1954, the Cooper Ornithological Society will meet jointly with Section F (Zoological Sciences) on Wednesday, December 29, at 2 p.m. in room 159 of the Forestry Building on the University of California campus. Six papers ranging from 15 to 35 minutes in length will be given.

The Annual Meeting of the Cooper Society will be held in 1955 at Asilomar, Pacific Grove, California. Reservations have been arranged for April 21 to 23. John Davis will serve as chairman of the committee on arrangements.

The business manager would like to advise members that the Cooper Society's Avifauna and Music in Nature records donated to schools or public libraries count as tax-deductible gifts. Some members have already made such valuable contributions. Why not make a gift of an Avifauna or set of Music in Nature records to the school or library in your city? We will make a suitable inscription when we mail it for you. Please give exact name and address of the school or library.—C. V. DUFF.

We report with regret the death of C. F. Batchelder on November 7, 1954, at the age of 98. Mr. Batchelder was the last surviving founder of the American Ornithologists' Union.

COOPER SOCIETY MEETINGS

SOUTHERN DIVISION

MAY.—The monthly meeting of the Southern Division was held on May 25, 1954, in the Allan Hancock Auditorium, University of Southern California, Los Angeles. Seven applications for membership were read, as follows: William J. Hamilton, III, 615 Highland Rd., Ithaca, N.Y., Jack Mantle, 3113 E. Lester St., Tucson, Ariz., and the Duke of Palmella, 140 Rua da Escola Politecnica, Lisbon, Portugal, proposed by C. V. Duff; Robert J. Bennett, 35-48 Steinway St., Astoria, L. I. C. 3, N.Y., proposed by David W. Johnston; Andreas B. Reznitzer, Scripps Institution of Oceanography, Univ. Calif., La Jolla, Calif., proposed by Alden H. Miller; Frank T. Keim, 4240 E. Cheery Lynn, Phoenix, Ariz., proposed by Jack C. von Bloeker, Jr.; and Daniel P. Schadle, 1029 E. Tuckey Lane, Phoenix, Ariz., proposed by John T. Wright.

Dr. Thomas R. Howell reported on the results

of the communications sent by the secretary, as instructed in the March meeting, to both of the senators from California, President Eisenhower, and the Secretary of the Interior, concerning opposition to the proposed establishment of Echo Park Dam within the boundaries of Dinosaur National Monument. Subsequently it was learned that the bill authorizing the dam had been defeated.

Mr. J. R. Pemberton gave a lecture entitled "Some Birds and Animals of Africa," illustrated with an extensive collection of Ectochrome slides taken in Kenya, Uganda and Tanganyika.—JACK C. VON BLOEKER, JR., *Acting Secretary*.

SEPTEMBER.—The monthly meeting of the Southern Division of the Cooper Ornithological Society was held on September 28, 1954, at the Los Angeles County Museum. The following names were proposed for membership: Kathryn L. Hardt, 207 E. Ave. 41, Los Angeles 31, Calif., and Mrs. Patricia Roe Snider, P. O. Box 504, Los Alamos, N.M., by Gale Monson; Robert David Burns, Dept. of Zoology, Univ. Calif., Los Angeles 24, Calif., and John E. Zoeger, 21421 Villena, Woodland Hills, Calif., by Thomas R. Howell; Gerhard Bakker, Jr., 1034 S. Mansfield Ave., Los Angeles 11, Calif., Harold Eugene Basey, 714 W. Clinton, Fresno, Calif., Mrs. Wm. A. Marshall, 15 Joann Court, Walnut Creek, Calif., Merriam Lee Miles, P. O. Box 191, Daytona Beach, Fla., Harry Roy Smith, 516-B Second St., Santa Cruz, Calif., and Fred H. Wagner, Game Biologist, Nevins State Fish Hatchery, R.R. No. 3, Madison 5, Wisconsin, by Jack C. von Bloeker, Jr.; David H. Woodside, P. O. Box 1761, Hilo, Hawaii, T.H., Fairbairn H. Armstrong, Box 97, Pomeroy, Wash., Alfreda Shuttleworth Glenn, P. O. Box 3992, No. Hollywood, Calif., Ray Herbert Greenfield, 1711 Mahani Loop, Honolulu 17, Hawaii, John R. Holt, 112 N. Oakhurst Dr., Beverly Hills, Calif., Louise de Kiriline Lawrence, Pimisi Bay, Rutherglen, Ontario, Canada, William E. Lofthouse, 6511 Pollard St., Los Angeles 42, Calif., and Ruth Marguerite Mason, Box 321, Hope, British Columbia, Canada, by C. V. Duff.

Dr. Hildegarde Howard presented the film, "Ornithology in the Museum." Ed N. Harrison showed two colored motion pictures taken by himself and Frances F. Roberts: "White Pelicans on Clear Lake" and "Life History of the Golden Eagle."—DOROTHY E. GRONER, *Secretary*.

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LIFE HISTORIES OF CENTRAL AMERICAN BIRDS

FAMILIES FRINGILLIDAE, THRAUPIDAE, ICTERIDAE,
PARULIDAE and COEREBOIDAE

By ALEXANDER F. SKUTCH

The Cooper Ornithological Society has recently published the Life Histories of Central American Birds as Pacific Coast Avifauna No. 31.

This volume contains life histories of 40 species of birds of Central America belonging to the higher families of song birds—the finches, tanagers, troupials, wood warblers, and honeycreepers. The accounts are the work of a skilled, sensitive and patient naturalist who has devoted a quarter of a century of outdoor work to the intensive study of the varied and complex bird life of the mountains and lowlands of Latin America. All but two of the accounts are heretofore unpublished and for each of the five families a summary and a comparison of the highlights of the breeding biology of the species are given.

Dr. Skutch, the author, was trained in botany at Johns Hopkins University. In 1928 he first visited the American tropics in Panama. There soon grew in him a determination to devote his life to learning all he could of the habits of the birds of Central America. Botanical jobs and finances were always adapted to the fullest possible pursuit of this goal in bird study. After work in Honduras and Guatemala, Dr. Skutch settled in Costa Rica in 1941 on his own farm in the wild and isolated section of El General. In support of this particular writing he received a fellowship from the Guggenheim Foundation, and in 1950 he was awarded the Brewster Medal of the American Ornithologists' Union for his publications on Central American birds.

The book consists of 448 pages, and it is illustrated by Don R. Eckelberry. A group of four tanagers is shown in color and all the other species are represented by line drawings. Thirty-two photographs show nests and habitats of tropical America.

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